SHORT NOTES

ORGANOCHLORINES IN ANTARCTIC MARINE SYSTEMS

By W. A. M. Courtney* *and* W. J. Langston†

Abstract. Sediment cores and various biological samples from Signy Island, South Orkney Islands, Antarctica, were analysed for PCB and *pp'*DDE. All samples, with the exception of one sediment sample, contained measurable quantities of PCB and *pp'*DDE. PCB concentrations were generally greater than DDE levels and PCB : DDE ratios were an order of magnitude greater in Signy Island fish and gulls than in migratory birds sampled elsewhere in Antarctica. PCB residues in some Antarctic areas may be the result of local human activities.

When DDT residues were found in Antarctic wild life more than a decade ago (George and Frear, 1966; Sladen and others, 1966; Tatton and Ruzicka, 1967), it was thought that the pollutants may have entered the region either in oceanic currents or, for example, in migrating birds and whales which were contaminated north of the Antarctic Convergence. Subsequently, atmospheric transport mechanisms were postulated (Risebrough and others, 1976) for both DDT and PCBs (polychlorinated biphenyls), although extremely low concentrations of PCB, one of the more common groups of marine pollutants, have been found in snow (Peel, 1975). Both local variation in PCB residues and high PCB : DDE ratios detected in the present study implicate humans as a possible source of local contamination in the Antarctic.

Samples were collected by British Antarctic Survey personnel from the research station at Signy Island (lat. 60° 43′S, long. 45° 38′W), South Orkney Islands, in March and April 1976, and stored in aluminium foil at −20°C during transportation to the laboratory for analysis. These samples included sediment cores, bivalves, limpets, fish and Dominican gulls. Thawed samples were weighed, ground with anhydrous sodium sulphate and extracted for 3 h with *n*-hexane in a soxhlet apparatus. Clean-up of the extracts was carried out on alumina columns (Holden and Marsden, 1969). PCB concentrations were derived from summation of individual component concentrations (total peak height) compared with standard chromatograms (Langston, 1978).

All samples, with the exception of sediment from Billie Rocks, contained measurable quantities of PCB and DDE (Table I). Other electron-capturing substances were detected in many samples but could not be identified with certainty.

Antarctic sediments and molluscs contain less PCB than sediments and bivalves from Southampton Water (Courtney and Denton, 1976) or Clyde bivalves (Holden, 1973). Predator/prey magnification of organochlorines may be indicated by larger residues in vertebrates compared with invertebrates. Both *Nacella concinna* and *Yoldia eightsii* appeared in one in three of the *Notothenia corriceps neglecta* sampled by Richardson (1975), although benthic amphipods form the bulk of the food of this fish. PCB in gulls, however, may well have been accumulated during their winter migration northward, for migratory birds contain more organochlorines than resident Antarctic species (Conroy and French, 1974). Contamination is not likely to have occurred through consumption of garbage. The Dominican gull is less prone to scavenge human debris in the Antarctic than skuas and sheathbills (personal communication from M. G. White). Comparison of the tissue extracts with standard chromatograms indicates selective accumulation of late-eluting pentachlorobiphenyls in fish and more highly chlorinated isomers, such as the heptachlorobiphenyls, in gulls.

Concentrations of PCB were generally greater than *pp'*DDE levels in the fauna analysed (Table I). No PCB was found in the giant petrel *(Macronectes giganteus)* from Signy Island

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TABLE I. PCB AND DDE IN ANTARCTIC SEDIMENTS AND FAUNA*

Sample	*Tissue*	*Locality*	*Number in sample*	*pp'DDE*	*PCB*	*PCB/DDE*
Sediment		Factory Cove	2	n.d.	13 (8.2–17.2)	
Sediment		Billie Rocks	2	n.d.	n.d.	
Nacella concinna	Whole	Factory Cove	20	1.9 (1.3–2.4)	15 (12.3–17.2)	8.3
Nacella concinna	Whole	Billie Rocks	20	1.6 (1.3–1.8)	4.3 (3.9–4.6)	2.8
Yoldia eightsii	Whole	Billie Rocks	1 (10)†	3.1	13	4.1
Laternula	Muscular foot	Billie Rocks	5	1.0 (0.7–1.3)	2.6 (1.2–4.9)	2.5
Notothenia neglecta	Liver	Bare Rock	2	2.3 (1.7–2.8)	110 (75.5–138)	54
	Muscle		2	1.6 (1.4–1.7)	56 (14.1–97.3)	39
Dominican gull	Liver		2	47 (15.2–77.8)	1 700 (256–3 225)	29
(*Larus dominicanus*)	Muscle		2	63 (7.3–118)	2 000 (109–3 825)	24
	Fat		2	1 500 (164–2 862)	58 000 (2 391–113 604)	27

* Wet-weight basis, 10^{-9} g g^{-1}. Means given with range where possible. n.d. None detected.
† Ten animals pooled.

analysed by Conroy and French (1974), although *pp'*DDE levels in the liver were only slightly lower than the residues in the Dominican gull which were similar to values in the blue-eyed shag *(Phalacrocorax atriceps)* taken on the island (Tatton and Ruzicka, 1967). Although PCB has not been detected in a number of Antarctic birds, values as high as 185 ppm in lipid have been found in the Wilson's petrel *(Oceanites oceanicus)* and the eggs of some species contain these pollutants (Risebrough and Carmignani, 1972), with contamination almost certainly occurring in non-breeding areas outside the Antarctic continent.

PCB : DDE ratios were an order of magnitude greater in fish and gulls of Signy Island than in the lipids of a variety of migratory Antarctic birds sampled by Risebrough and Carmignani (1972) elsewhere in Antarctica. High PCB : DDE ratios are usually associated with marine environments of the Northern Hemisphere rather than the Southern Hemisphere, and the DDT group predominated over PCB compounds in resident penguins on Doumer Island (lat. 64° 51.3′S, long. 63° 35.5′W) investigated by Risebrough and others (1976). PCB residues in Antarctic fish and gulls sampled in this study are comparable with values for plaice, cod and kittiwake in the North Atlantic (Bourne and Bogan, 1972; Zitko and Hutzinger, 1972). It is possible, therefore, that PCB residues in some Antarctic areas may be the result of local human activities. Higher residues in sediment and molluscs sampled close to the British Antarctic Survey research station (Factory Cove) compared with those collected from Billie Rocks 600 m away further indicate localized contamination of the Antarctic.

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THE PLACE-NAMES "GREATER ANTARCTICA" AND "LESSER ANTARCTICA" VERSUS "EAST ANTARCTICA" AND "WEST ANTARCTICA"

By Brian Roberts*

At least since the beginning of the century geographers have found it expedient to distinguish between the two parts of the Antarctic continent that lie on either side of the constriction formed by the massive indentations of the Ross Sea and Weddell Sea. The purpose of this paper is to put forward the view that the names "Greater Antarctica" and "Lesser Antarctica" are more appropriate and useful than the names "East Antarctica" and "West Antarctica" to designate the two unequal regions into which it is now clearly understood that the continent naturally falls.

All are agreed that, for practical purposes, the dividing line between these two regions may be considered to follow the line of the Transantarctic Mountains and, probably, the east side of Filchner Ice Shelf. In 1960, the names "Greater Antarctica" and "Lesser Antarctica" were approved by the United Kingdom Antarctic Place-names Committee. These names were originally proposed by the late Dr Edward Thiel and have the great advantage of being quite unambiguous (Thiel, 1961). The following provisional definitions were adopted for discussion:

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Greater Antarctica

A general name for the major region of Antarctica lying in the sector on the Indian Ocean side of the Transantarctic Mountains.

Lesser Antarctica

A general name for the minor region of Antarctica lying on the Pacific Ocean side of the Transantarctic Mountains. Lesser Antarctica includes the Antarctic Peninsula.

It was suggested that these names should be used in preference to "East Antarctica" and "West Antarctica" originally proposed by Balch (1902) for the lands south of Australia and south of South America, respectively. Nordenskjöld and Andersson (1905) followed this usage but without defining the limits of the regions, which were later clarified by Balch (1909) as the meridians of 0° and 180°. The original proposal remained useful so long as there were extensive tracts of unknown territory between the discoveries in the Antarctic Peninsula region and in Victoria Land, but it soon became apparent that authors were not using these names consistently. Furthermore, compound names like "Western East Antarctica" and "North-eastern West Antarctica" began to appear (Balch, 1912). The suggested use of capital or lower case letters did nothing to clarify this development.

It is confusing for Australians and New Zealanders to have "East Antarctica" to the westward and "West Antarctica" to the eastward (Roberts, 1959). The names "East Base" and "West Base" of the United States Antarctic Service of 1939–41, for example, were used in the reverse sense. Similar confusion arose from the divison of the Arctic Ocean into "East" and "West", with Russians and North Americans understanding these names in the opposite sense (Anonymous, 1955). From a standpoint at either pole, of course, both terms are meaningless, as in the classic 1937 newspaper reports describing the last known position of the lost Russian airmen as "300 miles west of the North Pole". By 1960 it was already obvious that continued use of these older Antarctic names would become even more confusing in discussion of new ideas about continental drift; more especially in reconstructions of Gondwanaland, some of which involve discussion of rotational movements of the Antarctic continent.

There is no doubt that names are needed for these two main regions of Antarctica. But few, if any, would now favour the meridians of 0° and 180° as the best dividing line, as this would include Coats Land and part of Dronning Maud Land [Queen Maud Land] in the wrong half from the point of view of their geological structure, although the line would have the merit of being precise. The natural structural division of Antarctica undoubtedly lies somewhere near a line joining the heads of the Weddell and Ross seas, but it is not yet possible to say exactly where. The "Tectonic map of Antarctica" (Craddock, 1970) shows the margin of the Ross orogen as generally following the flank of the Transantarctic Mountains through to Vahsel Bay on the Weddell Sea coast.

It has been contended in favour of the names "East Antarctica" and "West Antarctica" that they have been used and continue to be used very widely in the literature. This is certainly true. But authors have at no time been given a clear lead about any officially approved alternative names.

The confusion between "East Antarctica" and "West Antarctica" suggested that the four English-speaking place-name committees should try to join forces to intervene and give a firm lead, instead of merely following the current usage of authors who are interested in other more important problems and are usually quite willing to accept official rulings on such matters if these meet user needs. Acceptance of the terms "ice shelf" and "ice front", although the ambiguous term "ice barrier" had become deeply entrenched in the literature, provides a good example of this kind of necessary change in the naming of major features. Scarcely anyone now remembers that controversy; or the compromise which, after 52 years of dispute, at last enabled the conflicting names "Graham Land" and "Palmer Land" to become the "Antarctic

Peninsula", divided into these two lands. The only way to test which names shall prevail is to give publicity to the recommendations of the existing place-name committees.

I quote a comment by Dennis E. Hayes (1975). This is enshrined, surrounded in a black-lined rectangle, at the end of an editorial introduction to one of the reports of the Deep Sea Drilling Project of *Glomar Challenger,* 1972–73, when this research vessel was working in the Southern Ocean:

> "In parts of East Antarctica West Antarctica is east, in others west. This of course depends on if you are in east East Antarctica or west. However, if you are in west West Antarctica, East Antarctica is west unless you want to go to west East Antarctica in which case it is east. The same holds for east West Antarctica only in the reverse except that if you want to go to west East Antarctica, you still go east. No wonder we don't know what we found!"

The problem of agreement on the names for major regions of this kind, which straddle national interests, cannot realistically be decided by any one national committee acting alone. These authorities can decide the names to be used in their own official government publications. In the present case it is now clear that each authority should only make a *recommendation,* not a *decision.* These recommendations may eventually result in a consensus of opinion and common usage. We should certainly accept a transition period during which both usages continue.

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COMMENTS ON THE PAPER BY BRIAN ROBERTS

By G. HATTERSLEY-SMITH*

THE late Dr Roberts had two purposes in writing this paper: first, to present the case for what he considered the more logical pair of names for the two major regions of Antarctica; secondly, to determine through usage which pair of names would prevail after users had been given the chance to review the merits of the two pairs. He prepared several drafts of the paper, the final version being completed in the year that he died. Publication of the paper has been delayed in order to give time for full consideration and comment by the other three English-speaking Antarctic place-name committees, of Australia, New Zealand and the United States. Their comments have now been received.

* Secretary of the United Kingdom Antarctic Place-names Committee since 1976.

The Antarctic Names Committee of Australia, which approved the names Greater Antarctica and Lesser Antarctica in 1960, re-affirmed in 1978 its strong support for these names. The Committee thought that:

> "'Greater Antarctica' and 'Lesser Antarctica' are much more graphically descriptive terms than 'East Antarctica' and 'West Antarctica' because they describe a natural division of the continent. These terms also avoid the difficulty of determining a dividing line which relates reasonably to the East–West concept. The use of the terms East and West gives rise to ambiguities, for they may be used to describe a part of the continent, or a direction, or both. The compound use, for example, of such terms as Eastern East Antarctica is especially confusing."

The New Zealand Antarctic Place Names Committee, which approved the names Greater Antarctica and Lesser Antarctica in 1960, also re-affirmed in 1979 its "definite support" for this pair.

The United States Advisory Committee on Antarctic Names, which approved the names East Antarctica and West Antarctica in 1962, re-affirmed in 1978 its support for this pair, which it regards as firmly established among scientists and others involved with Antarctica. The Committee commented that:

> "A good deal of early confusion about the division of the major parts of Antarctica may have stemmed from the multiple orientations of published maps of the continent. These usually showed the publishing country at the top of the map. The members of the Working Group on Geodesy and Cartography of SCAR recognised the need for standardization and it was accomplished through a resolution adopted at the 5th meeting of SCAR in Wellington in 1961 which recommended that single sheet maps of Antarctica should be published with the Greenwich meridian pointing towards the top of the map. This decision on orientation neatly simplified the separation of East and West Antarctica. The practice now is almost universal . . . [There was no] substantial advantage to be gained by the name committees leading authors away from a satisfactory and established practice."

Although the United Kingdom Antarctic Place-names Committee approved the names Greater Antarctica and Lesser Antarctica in 1960, the names were not gazetted because of the lack of general acceptance. The Committee believes that the need for an unambiguous terminology for the two major regions of Antarctica is now greater than ever, and hopes that Dr Roberts's paper will help authors to determine which two pairs of names they will use in the future.

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OBSERVATIONS ON PARTICULATE MATERIAL IN SEA-WATER, DURING WINTER AT SIGNY ISLAND, SOUTH ORKNEY ISLANDS

By TERENCE M. WHITAKER

ABSTRACT. Three types of particulate material, assumed to be partly organic, were observed in the sea at Signy Island, South Orkney Islands, during winter. Some of these particles were incorporated into sea ice and were released into the water column as the ice melted. It is probable that this detrital material and material formed *de novo* is an important food source for particulate feeders during the Antarctic winter.

DURING the austral winters of 1972 and 1973 a large amount of particulate material was observed under fast ice at Signy Island, South Orkney Islands (lat. 60°42.5′S, long. 45°36′W). The particles consisted of three main types: phytoplankton and ice-associated micro-algal debris, flocculent aggregates (flocs) and yellow-brown platey fragments (flakes).

OBSERVATIONS

In situ

During a period of mean temperatures of −14.4°C, white fluffy particles were found floating in the sea-water under rapidly forming fast ice, by divers working in Factory Cove, Signy Island. *In-situ* observations (by the author) on 24 June 1972 revealed particles up to 1.5 cm in maximum dimension. The particles were more abundant at a depth of 8 m than immediately under the 35 cm of recently formed congellation and columnar sea ice. On 22 August, divers noticed accumulations of white amorphous particles on the sand and small-gravel substrate. At 16 m depth, drifts of this material up to 1 cm thick were present over a wide area but none was observed in the water. A sample of material and substrate was taken. The particles were whitish grey in colour and appeared as amorphous fluffy clumps. The clumps were irregular in outline, mainly flattened, but forming irregular balls 0.5–5 mm maximum dimension; most were 1–2 mm. Wet, in air on microscope slides, they showed a gelatinous texture and a nacreous sheen. Although fragile, they could be picked up between needle points. Microscopic examinations revealed no recognizable included fragments and very few bacteria. No chemical analyses were possible but the particles stained a faint yellow with iodine solution. The illustration in Silver and others (1978) shows a particle of similar morphology. Enquiry revealed several other workers at Signy Island had observed similar happenings in other years.

In early August 1973, dark patches were noted on the underside of fast ice in Borge Bay, Signy Island, and on 27 August a series of ten ice cores was taken at random, to a depth of 5 cm. Material from the melted cores consisted of diatom frustules, some microscopic seaweed fragments and many orange-brown platey particles with a size range 10–60 μm. The wet-ashing method of Strickland and Parsons (1965) was used to determine the carbon content of the samples as glucose equivalent. This ranged from 97.7 to 360 mg C m^{-2} (mean 201.5 ± 142.0). This suggested at least 1.6 g C m^{-2} in the whole of the fast-ice layer, which compares with 1.9 mg C m^{-2} in the whole of the 16.5 m water column. No living micro-algae were found in the ice cores.

Particles in preserved samples

Examination of membrane-filter permanent preparations made for phytoplankton-composition analysis showed a great variety of additional particles. Early and late in the winter period these often interfered with accurate cell counting. Samples in February and March showed detrital flocculent masses obviously derived from the summer phytoplankton bloom;

some were faecal in origin. In May–July, as sea ice formed, yellow-brown flocs (with no included diatom frustules) and orange-brown flakes became common. The yellow coloration observed in the flocs is possibly a preservation artifact. Later in the winter, especially after periods of fast-ice melt, very large numbers of particles of all three basic types were observed, usually most commonly in the lower parts of the water column (11–14 m depth). As summer approached, ice-associated diatom frustules were commonly associated with flocculent aggregates.

Discussion

The particles observed at Signy Island fall into three main categories: residual detrital material from the intense but short summer phytoplankton bloom, amorphous flocculent aggregates (flocs), and flat plates or flakes. Wiebe and Pomeroy (1972) reported organic aggregates from Antarctic and sub-Antarctic waters which closely resemble those observed at Signy Island. Field and laboratory studies suggest that *de novo* formation of organic particles from dissolved organic material is a common occurrence in all waters (Riley, 1970). The relative absence of bacteria and the sharp outlines of the flakes suggest that the Signy Island particles were newly formed, probably aided by the falling water temperatures and rapid increases of salinity associated with sea-ice formation. The sudden abundance of particles in early winter during conditions of rapid ice formation reinforces this theory.

It is suggested that particles of the floc and flake type form in late summer and early winter. Along with diatom detritus, these are incorporated into the congellation ice layers by ice crystals forming around them and floating them up in the water column. Later, the fast ice thins by melting underwater and the incorporated materials are released into the water column along with a variety of ice-associated micro-algae (Whitaker, 1977). This is probably the reason for extremely large carbon to chlorophyll ratios in samples from under fast ice at McMurdo Sound (Bunt and Lee, 1969).

The Signy Island observations of delayed organic turn-over may help resolve the winter survival problem posed to Antarctic particle feeders by the extreme brevity of the summer phytoplankton growth. At Signy Island this is less than 90 days (Horne and others, 1969). The amphipod *Pontogeneia antarctica* Chevreux was observed to consume brown platey detritus (flakes), and detrital material formed a major component of diet during early winter before ice-associated micro-algae appeared (Richardson and Whitaker, 1979).

Conclusions

The formation of particulate organic matter and its storage in fast ice may represent a regular food source for particulate feeders during the early part of the Antarctic winter.

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