# Biochemical Components of the Benthic Regions in Antarctic Waters

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## ABSTRACT

Biochemical composition of the Antarctic shelf and deep sea sediments have been studied. The carbon, nitrogen and phosphorus content was found to vary from 2.42 to 10.7,1.06 to 2.68 and 0.11 to 0.43 mg/g of dry weight, respectively. The values obtained are comparable to those found in some regions of Pacific Ocean and the Arabian Sea. Rich planktonic fauna in the overlying waters as well as the deposits from the glacial materials seem to be responsible for the fluctuation of the carbohydrate content of the organic matter. However, benthic biomass does not seem to be much related to the organic content of the sediments.

## INTRODUCTION

It is a known fact that the organic matter in the marine sediments is the characteristic feature of the processes like formation and destruction of organisms in the overlying waters and in sediments themselves. As a result of the involvement of the biogenic factors the composition of these organic materials may differ in space and time. The biochemical composition of these materials thus form a reliable index to clarify the diagenesis of the sediments and the conditions under which organic materials have been derived (Trask 1939).

During the First Indian Antarctic Expedition from December, 1981 to February, 1982, a valuable set of data was collected on the pelagic and benthic fauna of the Antarctic region. While sampling for benthic fauna it was possible to collect some samples for sediment analyses. In this communication the biochemical composition of the sediments from Antarctic benthic region is presented.

## MATERIALS AND METHODS

The sediment samples from the depth range of 220 to 3500 m (Table 1) were collected by deploying a 0.18 $m^2$ modified Petersen-Oken grab. The samples obtained were immediately frozen on board the ship.

In shore laboratory the sediment samples, before analyses, were thawed, air dried and ground to fine powder and then used for the estimation of the biochemical analyses. Organic carbon was determined by the wet oxidation method (El-Wakeel and Riley 1957). The amount of organic matter was obtained by multiplying the organic carbon values by a factor of 1.82 (Romankevich and Artem'yev, 1969). Carbohydrates were determined by the phenol-sulphuric acid method described by Dubois *et al* (1956). The total nitrogen was estimated by Kjeldahl digestion and persulphate oxidation to nitrate (Koroleff, 1972). The total phosphorus was determined by perchloric acid digestion method (Jackson, 1967).

## RESULTS AND DISCUSSION

Organic carbon content was found to vary from 2.42 to 10.7 mg/g of the dry sediment, the maximum and the minimum values being observed at stations G-l and G-2 respectively (Table 1). Organic detritus in the overlying waters is the major contributor of the organic matter to the sediments (Bordonovsky 1965) and the general distribution of its content show increased values in the productive areas like nearshore sediments in the upwelling regions (Trask 1932).

The organic carbon of the marine sediments in the upwelling regions of west coast of India have been reported to range from 13.2 to 62.0 mg/g (Bhosle *et al* 1978), while in the Central Pacific Ocean which is relatively less productive area the values were found to range from 0.7 to 4.5 mg/g (Artem'yev 1970). In

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Kuril-Kamchatka trench the sediment organic carbon was found to vary from 12.0 to 15.0 mg/g, the major contribution of which is ascribed to the planktogenic suspended organic matter (Romankevich and Artem'yev 1969). The values of sediment organic carbon obtained in the present analysis is much lower than that reported for the waters in the Arabian Sea (Bhosle *et al* 1978) but can be compared well with those for the other, two regions mentioned above (Romankevich and Artem'yev 1969, and Artem'yev 1970). Since the Antarctic waters also sustain high yield of production during the fair season (see Prabhu Matondker, Qasim and Goswami etc., in this report) it may be pointed out that major portion of the sediment organic carbon in the region could have been derived from the planktogenic sources. However, no substantial relation as observed between the organic carbon content of shelf region and deep sea sediments could be observed.

TABLE 1

*Biochemical composition of Antarctic marine sediments*

| SI. No. | Stn. No. | Co-ordinates Latitude (S) | Co-ordinates Longitude (E) | Depth (m) | Texture | Organic carbon (mg/g) | Carbo-hydrates (mg/g) | Total Nitrogen (mg/g) | Total Phosporous (mg/g) | C/N Rate | Organic matter (mg/g) | Carbo-hydrate % organic matter |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | G-l | *67°13.5`* | 39°12.3' | 3580 | Gayey silt | 10.70 | 1.64 | 1.39 | 0.15 | 7.70 | 19.46 | 8.43 |
| 2. | G-2 | 69=58.14' | 11°54.65' | 227 | Calcareous sand with mixture of clay | 5.87 | 2.12 | 1.29 | 0.12 | 4.55 | 10.67 | 19.87 |
| 3. | G-3 | 69°00` | 13'41.05' | 2337 | Clay with brownish | 3.80 | 2.18 | 2.68 | 0.43 | 1.42 | 6.91 | 31.55 |
| 4. | G-4 | 68° 43.5' | 11°06.7' | 1661 | Clay with gravel and small stones | 4.49 | 1.39 | 1.32 | 0.22 | 3.40 | 8.16 | 17.03 |
| 5. | G-5 | 68°24.65' | 17°11.67` | 2O70 | Clay, yellowish in colour with small pellets & small stones | 3.80 | 1.74 | ND* | 0.14 | ___ | 6.91 | 25.18 |
| 6. | G-6 | 67°46.37' | 12°00.04' | 1990 | Clay, greenish in colour | 2.42 | 1.78 | 1.06 | 0.13 | 2.28 | 4.40 | 40.45 |
| 7. | G-14 | 45°38.07' | 40°24.62' | 1680 | Sandy, white with sticky ooze | 5.18 | 0.72 | 2.20 | 0.11 | 2.35 | 9.42 | 7.64 |

***ND** - Not detectable

The carbohydrate content in the Antarctic benthic region was found to vary from 0.72 to 2.18 mg/g of the dry sediment (Table 1). The carbohydrate values were much lower at station G-14 whereas at other stations it was high. This indicates the influence of the glacial,materials on the carbohydrate content of these sediments (Table 1). The mean carbohydrate value of 1.65 mg/g observed in the present analyses is much below the average value of 6.37 mg/g obtained for the continental shelf sediments along the west coast of India (Bhosle *et al* 1978). But the present values can be compared well with those ranging from 0.37 to 1.66 mg/g (dry sediment) for Kuril-Kamchatka trench (northeast Pacific Ocean) and those from 0.21 to 1.61 mg/g for the Central Pacific Ocean (Artem'yev 1969,1970).

The carbohydrate content is a reliable index of the readily assimilable organic matter in the sediments and therefore its proportion in the organic matter was determined. This percentage of carbohydrate in the organic matter was found to be highly fluctuating and varied from 7.64 to 40.45% (Table 1). It was also observed that the carbohydrate-content did not show much relation with organic carbon distribution. The carbohydrates or carbohydrate like substances found in deep sea pelagic sediments may not only be residual products of the zoo- and phytoplankton but also neogenic. The microorganisms are known for their important role in generating carbohydrate in the surface bottom sediments, (Degens *et al* 1964, Prashnowsky *et al* 1961). Besides, the bottom fauna may substantially change the composition of the organic matter in the sediments resynthesising the carbohydrates from non-carbohydrate sources (Zobell 1939). All these processes either individually or in combination could have been responsible for the lack of relation between organic carbon and carbohydrate percentage in the organic matter of Antarctic sediments.

The nitrogen which is the basic component of the living matter may be present in the sediments as pigments, humic acids, bitumens and also readily hydrolyzable forms like amino acids (Bordovsky 1965). A part of the dissolved forms of nitrogen may be incorporated in the absorbing complex of sediments and thus be firmly bonded with the mineral skeleton in sediments. Therefore, although the nitrogen content in the sediment is in the main, intimately related to overall content of organic matter and is often used as an indicator of the organic concentration, it should be remembered that, part of the nitrogen which has been trapped in the mineral fraction of sediments is not directly related to the organic matter (Bordovsky 1965). The amount of fixed nitrogen captured by the crystalline lattice of the mineral and present in fixed state in sedimentary rocks has been reported to vary between 10 to 66% depending on the mineralogical composition of the clay fraction (Stevenson 1960).

The nitrogen content of the Antarctic sediments was found to vary from 1.06 to 2.68 mg/g of dry sediment (Table 1) with a mean value of 1.42 mg/g. The high content of nitrogen was found to be associated with the sediments containing sticky ooze at stations G-3 and G-6 whereas the values approached to almost undetectable levels at stn. G-5 where the sediment constituted of rocky pellets. These observations are in accordance with those of Trask (1932) and many others (Bordovsky 1965, Bhosle *et al* 1978) who established that nitrogen content is related to the particle size of the marine sediments, the proportion being higher in clay muds than in sands. Moreover, the ooze is mainly composed of the remains of the planktonic foraminifera and calcareous nannofossils which could have possibly given rise to levels of nitrogen content.

C/N ratio (weight) in these sediments (Table 1) was found to vary from 1.42 to 7.70 with an average value of 3.6. This indicates that the sediments have high nitrogen containing organic matter. The average C/N ratio in marine organisms lies between 5.9 for phytoplankton to 6.3 for zooplankton (approximate figure for marine bacteria being 5 (Bordovsky 1965). During the course of sedimentation, the decomposition and subsequent remineralization may drastically alter the carbon and nitrogen content of organic matter, which in turn reflect on the C/N ratio.

Gulyayeva (1956) pointed out that the organic remains incorporated in the sediments in oxidation zone could be modified in accordance with the environmental conditions whereby nitrogen content could be increased, ultimately reducing the C/N ratio. Under conditions of moderate oxidation the organic matter is usually depleted of nitrogen and C/N ratio may thus be slightly elevated. Trask (1932) through his extensive investigations established C/N ratio varying between 5.3 to 13.6 with an average value of 8.4. Various other investigators have also obtained similar or even higher values for marine sediments (Romankevich & Artem'yev 1969, Barder *et al* 1960, Gorshkova 1955 and Klenova 1948). The average value of C/N ratio obtained in the present analysis appears to be much lower than the mean value of 8.4 reported by Trask (1932). Artem'yev (1970) while describing the C/N ratio for Central Pacific Ocean indicated that the low ratio could be due to the selective preservation of small part of stable nitrogen compounds during the conditions of active oxidation of organic matter. The similar reason seems to be applicable for the low ratio encountered in the present analysis, especially in the sediments containing clayey ooze.

The total phosphorus in these analyses includes different forms of phosphates like interstitial, adsorbed, organic and inorganic-insoluble phosphates. The phosphorus concentration in the Antarctic sediments was found to vary from 0.11 to 0.43 mg/g of of dry sediment. These values can be compared well with those reported by Murty *et. al* (1968) for continental shelf waters off the west coast of India.

Commonly occurring forms of mineral phosphates in the sedimentary environments are calcium phosphate generally known as phosphorites (Degens 1965). It has been accepted recently that part of the phosphorites may be derived from the organic activities. That is, it is initially collected by photosynthetising marine organisms and carried to the ocean floor as phosphate after death via detritus (tripton). During decay much of the phosphorus could be released and be available for phosphate formation. However, quantitatively it is difficult to estimate how much of phosphorus has come from organic debris and how much is directly extracted (inorganically) during exposure of cabonates to phosphate enriched sea water. Aside from the development of extensive phosphorite deposits, phosphatization of all kinds of organic residues such as shell materials, wood, faecal pellets, teeth, etc , is common feature in marine environments (Goldberg and Parker 1960, Adams *et al* 1961, Arrhenius 1963). Guano deposits may also represent another source of phosphate accumulation especially derived from vertebrate excretion. Depending on their biological source one may distinguish between bird guano, sea lion guano or bat guano. Numerous examples of the phosphate formation whithin the guano and in the rock formation underlying the deposits have been elaborated by Hutchingson (1950) and Clarke (1924). The higher phosphate contents encountered at stations G-1 to G-6 as compared to G-14 may be due to proximity of the former stations with the Antarctic landmass and thus indicate their origin from biological activity. Besides this, the dissolved phosphate contents of the overlying waters was also found to be quite high (refer Sengupta and Qasim in this report) which may in turn affect the phosphate contents adsorbed on the sediment surface.

An attempt made to correlate the biochemical composition with the distribution and abundance of benthic organisms (Paruleker, Ansari and Harkantra in this report) revealed an indiscreet relationship, as against positive correlation with the column productivity (Prabhu Matondkar and Qasim in this report).

## REFERENCES


Adams, J.K., Groot, J.L. and Hiller, Jr. N.W. (1981)
Phosphatic pebbles from brightseat formation of Maryland. *Journal of Sedimentology & Petrology.* 31; 546-552.

Arrhenius, G.( 1963).
'Pelagic sediments' In *The Sea,* ed. Hill M. N. Interscience, N.Y. pp. 655-727

Artem'yev, V. Ye. (1969)
Carbohydrates in bottom sediments of the Kuril-Kamchatka trench. *Oceanology 9 :* 203-206.

Artem'yev V. Ye. (1970)
Carbohydrates in the bottom sediments of the Central Pacific. *Oceanology* 10:508-512.

Barder, R.G.,Hood, D.W. and Smith, J.B. (1960)
Study of dissolved organic matter and its adsorption by discrete particles in sea water. A *Geochimica et Cosmochimica Acta* 18 : 236-243

Bhosle, N.B., Dhargalkar, V.K. and Braganza, A.M. (1978)
Distribution of some biochemical compounds in sediments of the shelf and slope regions of the west coast of India. *Indian Journal of Marine Sciences 7 :* 155-158.

Bordovsky,O.K. (1965)..
Accumulation and transformation of organic substances in marine sediments. *Marine Geology 3 :*3-114.

Clarke, F.W. (1924).
*The data of geochemistry* (fourth edition). Govt. Printing Office, Washington D.C.

Degens, E.T. (1965).
*Geochemistry of sediments — a brief survey.* Prentice-Hall, Inc. Englewood Cliffs, New Jersey, pp. 141-152.

Degens, E.T., Reuter, H.J. and Shako, N.F. (1964)
Biochemical compounds in offshore California sediments and seawaters. *Geochimica et Cosmochimica Acta* 28 :45-66

Dubois, M., Gilles, K. A., Hamilton, J.K., Reebers, P.A. and Smith, F. (1956)
Calorimetric method for determination of sugars and related substances. *Analytical Chemistry 28:*350-360.

El-Wakeel S. K. and Riley, J. P. (1957)
Determination of organic carbon in the marine muds. */. cons. perm. int. Explor. Mer* 22 : 180-184

Goldberg, E.D. and Parker, R.H. (1960)
Phosphatized wood from the Pacific Sea floor. *Bulletin of the Geological Society of America.* 71 : 631-632.

Gorshkova, T.I. (1955)
Organic matter in the Sea of Azov and Taganrog Bay.TV. *Vses. Nanchn. Issled. Morsk. Rybn. Khoz. I. Okeanogr. 31*: (1) (Russian)

Gulyayeva, L.A. (1956).
The geochemistry of the Devonian and carboniferous deposits of the Kuybyshev area of the Volga. *Izd Akad. Nauk S.S.S.R.* Moscow (Russian).

Hutchinson, G.E. (1950)
Survey of existing knowledge of biochemistry: 3. The biochemistry of vertebrate excretion. *Bulletin of American Museum of Natural History 96:* 1-544.

Jackson, M.L. (1967)
Phosphorus determinations for soils. In: *Soil Chemical Analysis,* pp. 134-182.

Klenova, M.V. (1948)
*Marine Geology** Uchpedgiz, Moscow (Russian)

Koroleff, F. (1972)
Determination of total nitrogen in natural waters by means of persulphate oxidation. In "International Council for the Exploration of the Sea". *Cooperative Research Report* 29

Murthy, P. S. N., Reddy, C. V. G., and Varadachari, V. V. R. (1969)
Distribution of organic matter in marine sediments of the west coast of India. *Proceedings of National Institute of Sciences* .35, B : 377-384

Prashnovsky, A., Degens, E.T., Emery, K.O. and Pimenta, J. (1961).
Organic matter in the recent and the ancient sediments Part 1. Sugars in sediments of the Santa Barbara Basin California, *Jb. Paleont. Monaths* No. 8.

Romankevich, Ye. A. and Artem'yev, V.E. (1969)
Composition of organic matter of sediments from Kuril-Kamchatka Trench, *Oceanology* 9:644-653

Stevenson. F.J. (1960)
Chemical state of the nitrogen in the sedimentary and igneous rocks. *Bulletin of Geological Society of America* 77(12).

Trask, P.D. (1932)
*Origin and environment of source sediments of petroleum.* Gulf Publ. Co., Houston, Texas, pp. 323.

Trask, P.D. (1939).
Organic content of recent marine sediments. In: *A symposium on 'Recent marine sediments'* Ed. by Trask, P. D., Dover Publ. Inc. N. Y. pp. 428-453.

Zobell, C.E. (1939).
Occurrence and activity of bacteria in marine sediments. In: *Symposium on 'Recent marine sediments'* Ed. Trask, P. D., Dover Publ. Inc. pp. 416-427.

* Not Consulted in Original