La mer 24: 1-2, 1986
Société franco-japonaise d'océanographie, Tokyo

Article spécial n° 5

Marine chemistry or chemical oceanography*

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Is marine chemistry really an independent discipline, with its own goals and its own scientific satisfaction, or is this just a fiction? Whether marine chemistry is a subdiscipline of biological, geological or physical oceanography is little debated, but this question is certainly worth asking. Oceanographic institutes know that when they attract young chemists into the field of marine chemistry, a number of them will sooner or later become disappointed as they experience that they are not carrying out the kind of science for which they thought they had been educated. This happens particularly with chemists who consider chemistry to be the science of synthesizing new chemical products, in connection with the study of the molecular structures of compounds and the determination of their physicochemical properties. Such disappointment seems to occur mostly with newly graduated chemists who not have the slightest notion of what the sea actually is and certainly know nothing about its unstable surface which renders them sea-sick.

Fortunately there remain a few young chemists who stay in their new chosen discipline and become dedicated to the oceans and their marginal seas. Their reason for doing so, however, requires further reflection. They will not go on to synthesize new substances and rarely will carry out research on molecular structures of individual compounds. Hence, the question remains, what their major achievements in chemistry will be, and what the highlights in the general advancement of marine science in fact are.

* Received January 16, 1986
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In the early days of marine chemistry the chemist started as an analytical chemist, whose achievements were connected with the development of analytical techniques and their application in the various conditions encountered in doing and participating in ocean research. Marine chemistry as such was a basic part of either physical, geological or biological oceanography.

In order to avoid being no more than technicians for these disciplines, the chemists called themselves chemical oceanographers, with the emphasis on the second term. Many chemical oceanographers of the first days such as Herman WATTENBERG (G), H.W. HARVEY (UK), Kurt KALLE (G) and Norris RAKESTRAW (USA) were pioniers in the science of understanding the basic processes of water-mass movements and the cycles and budgets of substances in the

sea. These were essential for oceanography in the early years.

With the improvements of modern analytical techniques and the specialization of education in marine chemistry, the role of chemists has become much more sophisticated. This, however, at the risk of losses for the impact to studies of other oceanographical disciplines.

Marine chemistry has partly become a specialization in itself, and most satisfactory studies can already be done in no more than 1 m*l* of sea water. Nevertheless these specializations remain almost entirely analytical. The impact of the results of such studies on the functioning and structure of oceanic geochemical and ecological systems remains restricted in value or is indeed absent. The danger of becoming simply a technician in this case of one's own discipline is always present, in spite of the fact that the marine chemist is able to identify dozens of peaks from the computerized read-out of his analytical equipment, and his results and manuscripts may be generously accepted for publication in one of the well-cited journals. Although scientists from other disciplines, in particular biology, may wonder what the value of such studies really is, the reward for the marine chemist is many citations.

For these other marine scientists this is, however, not without concern. Marine biologists, physicists and geologists cannot make progress in their own science without good chemical data. A problem arises when they try to produce these data themselves; this is not the most effective way of working, and there is a loss of accuracy in analysis and interpretation of results. Oceans, marginal seas and estuarine ecology studies require the combined efforts of many disciplines, including those of geochemists, biochemists and microbiologists. In this sense, environmental chemistry is a better term than marine chemistry or chemical oceanography, although each one keeps its own value.

The question remains, however, what is the 'glue' which can bind the efforts of other disciplines with those of marine chemistry, and thus increase the impact of the chemical research carried out in the sea. The answer is the same as that given by the chemical oceanographers of the first days: try to understand processes, on a micro-scale within organisms, sediment and water, or on a macro-scale within water masses, taking into account time, space and state of equilibrium. There is no doubt that this is of multi-disciplinary interest, although the regard in which the articles is held by the scientific world may require more time. Specialists in mono-disciplines are particularly good in self-defence and the citation scores of their publications are usually higher than those of authors who try to broaden their own field of research over the boundaries of different disciplines.

In many instances, where marine chemists have been involved with other disciplines, the initiative for cooperative inter- or multidisciplinary studies has been taken by the other disciplines. Why is this the case? Obviously, as already stated, biological, physical and geological oceanography requires chemical data and the scientists in these disciplines have been forced to take steps to secure it in the best possible manner. But perhaps chemists have been too self-content, or perhaps too shy, to take the initiative themselves to broaden their frontiers over the boundaries of their discipline?

I personally think that it is time for us to take this step, and to venture beyond our boundaries, particularly in the field of aquatic ecological research, studies on diagenesis in geology and sedimentology, and modelling of transfer and transport processes with respect to physics. Overlapping and competition may occur, but is this not always to the profit of science?

Oceanography, in whatever scientific compartment it is carried out, is in its parts as well as in its entirely a tremendous study. Geographically, it concerns 70 % of our globe, and the problems of one country with regard to fishery, pollution, ecosystem protection and exploitation are those of the other. This unifies many scientists over the whole world; good scientific articles from their hands are recognized without regard to nationality or creed. Let us trust that it will remain like this and that both marine chemistry and chemical oceanography will have a great future.