

Wolfgang Schott (1905–1989): the founder of quantitative paleoceanography

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Abstract Wolfgang Schott is the pioneer in paleoceanography and has established this research field within marine geology. His papers from the first half of the twentieth century are all published in German; therefore, the most inspiring results are given here as original quotes in English, since they paved the ground for all scientific discussions on climate stratigraphy, past ocean currents, and glacial interglacial cycles.

Keywords Paleoceanography · Climate stratigraphy · Past ocean circulation · Foraminifera · Deep sea sediments

Introduction

When he was still a student of geology, Wolfgang Schott assisted his father at the Deutsche Seewarte (German Marine Observatory) in Hamburg during his semester vacations, helping to analyze current measurements which had been obtained by the survey vessel PANTHER in the German Bight. In 1927, he was on board the national research vessel POSEIDON during an expedition to the Barents Sea and to Svalbard to investigate the regional hydrography (Kockel and Stackelberg 1990).

The large-scale distribution of pelagic organisms, especially foraminifera, in relation to sea surface temperatures had already been described at the end of the nineteenth century (e.g., Murray 1897) and showed up in the classical text book of Karl André (1880–1959; 1920:280ff). In contrast to these qualitative descriptions, Wolfgang Schott analyzed the mineral fraction as well as the biotic composition of foraminifera assemblages quantitatively. Based on these results, he could demonstrate that the variability and frequency of distinct minerals and foraminifera species reflected the dynamics of water masses, which in turn portrayed climate variability. This research approach was one of the most significant breakthroughs in modern paleoceanography.

Biography

Wolfgang Schott (Fig. 1) was born on February 1, 1905, in Hamburg-Altona (Northern Germany), son of the well-known oceanographer Gerhard Schott (1866–1961) who served as a scientist at the Deutsche Seewarte in Hamburg. After his secondary school exams (Abitur), Wolfgang Schott began his studies in geology in Göttingen and continued his courses at the universities of Freiburg (Breisgau), Hamburg and Graz (Austria). In 1927, he started to work for his doctorate under the supervision of Hans Stille and Roland Brinkmann on the topic of “paleogeographical problems of the Jurassic formation in northwest Germany.”

Immediately after his Ph.D. examinations on March 4, 1930, he started his academic career as assistant to Carl W. Correns (1893–1980), a mineralogist and geochemist specialized in sedimentology at Rostock University, where he stayed until 1934. Correns participated in the German Atlantic expedition of the METEOR in 1926/1927 and

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Fig. 1 Prof. Wolfgang Schott (1905–1889). Foto: Archiv BGR

asked W. Schott to analyze the surface sediment samples as well as the sediment cores. This research, published in 1934, paved not only the way for the biostratigraphy of deep sea sediments but also shed light on the varying carbonate content of the oceans with depth, which was later fully investigated within the framework of the Deep Sea Drilling Project (Berger 1976) and proved to be crucial for the interpretation of ancient marl and limestone alternations (Ricken 1986). Moreover, Schott demonstrated that the quantitative distribution patterns of planktonic foraminifera in the sediment perfectly reflect sea surface temperatures and water masses. This in turn provided a means to differentiate between warm and cold periods, in other words between ice ages and warm stages. Hence, Wolfgang Schott can be regarded as the founder of modern paleoceanography and climate stratigraphy. Further important papers followed (1937, 1938a, b), which focused not only on the Atlantic but also on the Indian and Pacific Oceans.

In 1934, Wolfgang Schott joined the Prussian Geological Survey at the branch of hydrocarbon research in Hannover under the leadership of Alfred Bentz. Besides investigations on marine sediments and marine geological scientific issues, his research focused more on paleogeographical and sedimentological studies as well as facies-related issues within the framework of the national drilling program. In 1940, he was promoted to district geologist and was also



Fig. 2 Chief scientist discussion on RV METEOR 1964: (from top right in anticlockwise direction: Günter Dietrich, Wolfgang Schott (white shirt), Friedrich Defant, Johannes Krey, Fritz Holzkamm, Klaus Graßhoff, N.N., Gunther Krause, Johannes Ulrich, Reimer Simonsen. Foto: Archiv Prof. Siedler

appointed as lecturer at the University of Göttingen. Subsequently, hydrocarbon geology formed his second major scientific interest, initially in northwest Germany. Later, he investigated hydrocarbon deposits in Romania and Ukraine as head of the regional geology department within the Office of Soil Research in Hannover. After World War II, he remained with the newly founded Federal Office of Soil Research and was appointed head of the hydrocarbon division, subsequently as part of a joint position with the geological survey of Lower Saxony.

As a result of his international reputation and personal integrity, he was invited by the Oceanographic Institute of Göteborg (Sweden) in 1947 to study the sediments from the Swedish “Albatross-expedition” (Kockel and Stackelberg 1990). The important results of this research were published in 1952. In 1958, he became director of Division III of the Federal Office of Soil Research, which he enlarged by the creation of the new research unit “Marine Geology.” In 1960, he was invited by the University of Miami to take part in the “Carib” expedition, and in 1964/65 he participated in the German expedition into the Indian Ocean with the new METEOR (Fig. 2). From 1965 until 1972, he lectured as honorary professor at the University of Göttingen. Professor Schott is not only known as the father of paleoceanography but also as an internationally recognized specialist in hydrocarbon geology. He studied hydrocarbon fields in Portugal (1952), Yemen (1952), Saudi Arabia (1954), Syria (1955), and India (1955, 1957). In 1960, he was consultant for the Chilean government regarding earthquake issues. Wolfgang Schott passed away on July 9, 1989, in Hannover (Kockel and Stackelberg).

Relationship between climate variability and marine sediments

The marine geologist Wolfgang Schott, through his quantitative analysis of micropaleontological data, laid the foundation for the research discipline paleoceanography during the period between the two World Wars. A few text passages cited as translations from his original papers give a glimpse into his brilliant mind (Schott 1934:48) “A detailed knowledge of the deposits on the present day sea floor may be of fundamental importance for geology since the formation and origin of recent marine sediments may clarify important geological and biological questions of the past.” And further on p. 49: “The profiles of the present day sea floor enable a view into an eventual variation of the sediments in deeper layers and may reveal information on the stratification, which occurs frequently in fossil sediments and which has been denied in recent sediments for long time.” In this early paper, Schott documented his quantitative approach for the interpretation of the distribution of planktonic foraminifera (p. 50) “... by counting about 500 specimens in each sample ...” To use these data, stratigraphically Schott wrote (p. 50f): “To interpret the faunistic changes within individual profiles, a regional overview about the foraminifera fauna on the present day sea floor is required and since the calcareous tests of the pelagic foraminifera constitute the majority of all foraminifera on the sea floor, a comparison with the habitat of these foraminifera in the uppermost layers of the water between 0–100 m would be welcome.”

From very early on Wolfgang Schott was particularly interested in the spatial distribution, based on the comparison of results from different expeditions, of sediments on the open ocean floor. He demonstrated the clear link between climate zones, ocean currents, and the distribution patterns of surface sediments. In the treatise on the geography of the Indian and Pacific Oceans (electronic supplement), published in 1935, he stated on p. 118: “New and noteworthy is the narrow strip of diatomaceous ooze parallel to the west coast of South America, which extends from 2° to 36° southerly latitude, according to what is known from the cruises of ‘WILLIAM SCORESBY’ in 1931. This occurrence of diatoms on the South American west coast cannot, therefore, be compared to those from the polar latitudes.” And further on p. 119: “The *Globigerina* ooze occurs mainly in tropical to temperate latitudes. This sediment, whose character is controlled by material derived from the ocean water, namely foraminifera, only occurs there because the foraminifera which comprise it are thermophilic, pelagic animals avoiding cooler water regions. In zones of cooler surface waters, the pelagic plant group diatoms prevail. Therefore, the sea floor of these regions is mainly covered by diatomaceous ooze. The difference

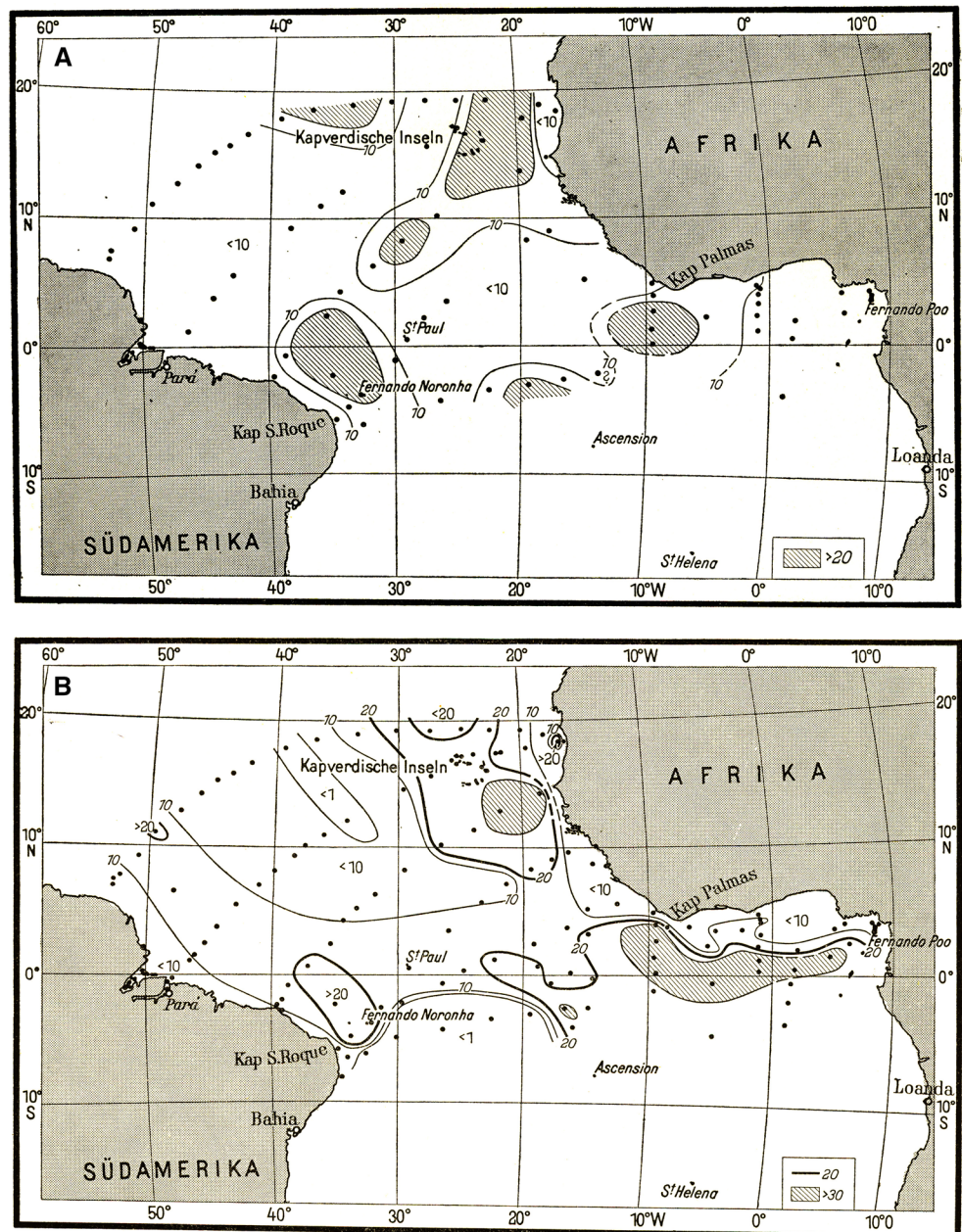
between the inhabitants of these two types of surface water is so clearly mirrored in the seafloor sediments that, in the south, the *Globigerina*/diatomaceous ooze boundary coincides almost exactly with the subpolar convergence boundary of these two surface water masses. For the same reason, the diatomaceous ooze in the northwest Pacific Ocean ceases approximately where the winter convergence line falls, and the narrow strip of diatoms along the South American west coast is therefore inevitably explained by cool upwelling water on this coast.”

It is both amazing and laudable that Carl W. Correns, his head of department between 1930 and 1934 in Rostock, immediately included Schott’s results and new findings in his textbook “On the Origin of Rocks” (Barth et al. 1939: 160, 194–196, 243) with special focus on the lithological aspects of Schott’s papers.

Wolfgang Schott clearly documented the close relationship between water masses and/or climate zones and the distribution of pelagic organisms in marine sediments and, therefore, established Quaternary marine stratigraphy as climate stratigraphy (Schott 1937:122): “The dominant occurrence of *Globigerina bulloides* and *Globigerina inflata* prevailing in present day cooler water, as well as the disappearance of the thermophilic and presently widely distributed *Globorotalia menardii* in the *Globorotalia menardii* free zone indicates that, during the deposition of the *Globorotalia menardii* free strata, the sea surface water of the equatorial Atlantic Ocean was cooler than today. This decrease in temperature of the equatorial ocean water can only be explained by the ice age.”

One of these seminal papers (Schott 1938b) was excellently translated by C.J. Adams and J. Schönfeld and published in the “Golden Volume” of the Geologische Rundschau edited by Dullo et al. (2003:51–53). Spatial changes in the sedimentary cover are equivalent to temporal changes (Walther 1894), and hence Schott (1937:120) wrote: “... the author was able to prove, using samples from the METEOR expedition to the equatorial Atlantic Ocean and based on the stratigraphy of the present-day deep sea sediments established by a quantitative investigation of the foraminiferal fauna, that the *Globigerina* ooze has become more widespread since the end of the Diluvium (Pleistocene) and advanced relative to the red clay and the hemipelagic ooze, which means it has transgressed over the red clay and the hemipelagic ooze. At the same time, the *Globigerina* ooze spread over the diatomaceous ooze area in the south of the oceans. This transgression of the *Globigerina* ooze over the diatomaceous ooze can now be interpreted. During the Diluvium (ice age), the subpolar convergence zone was located at lower latitudes than today as a result of the expansion of the region covered by cool surface water. The penetration toward lower latitudes of drift ice loaded with debris during the ice age is also confirmed by various occurrences of

Fig. 3 **a** Distribution of *Globorotalia menardii* (d’Orbigny) in % of the total foraminiferal fauna within 0–100 m water depth derived from net catches. **b** Distribution of *Globorotalia menardii* (d’Orbigny) in % of the total foraminiferal fauna on the present-day seafloor. After Schott (1937)

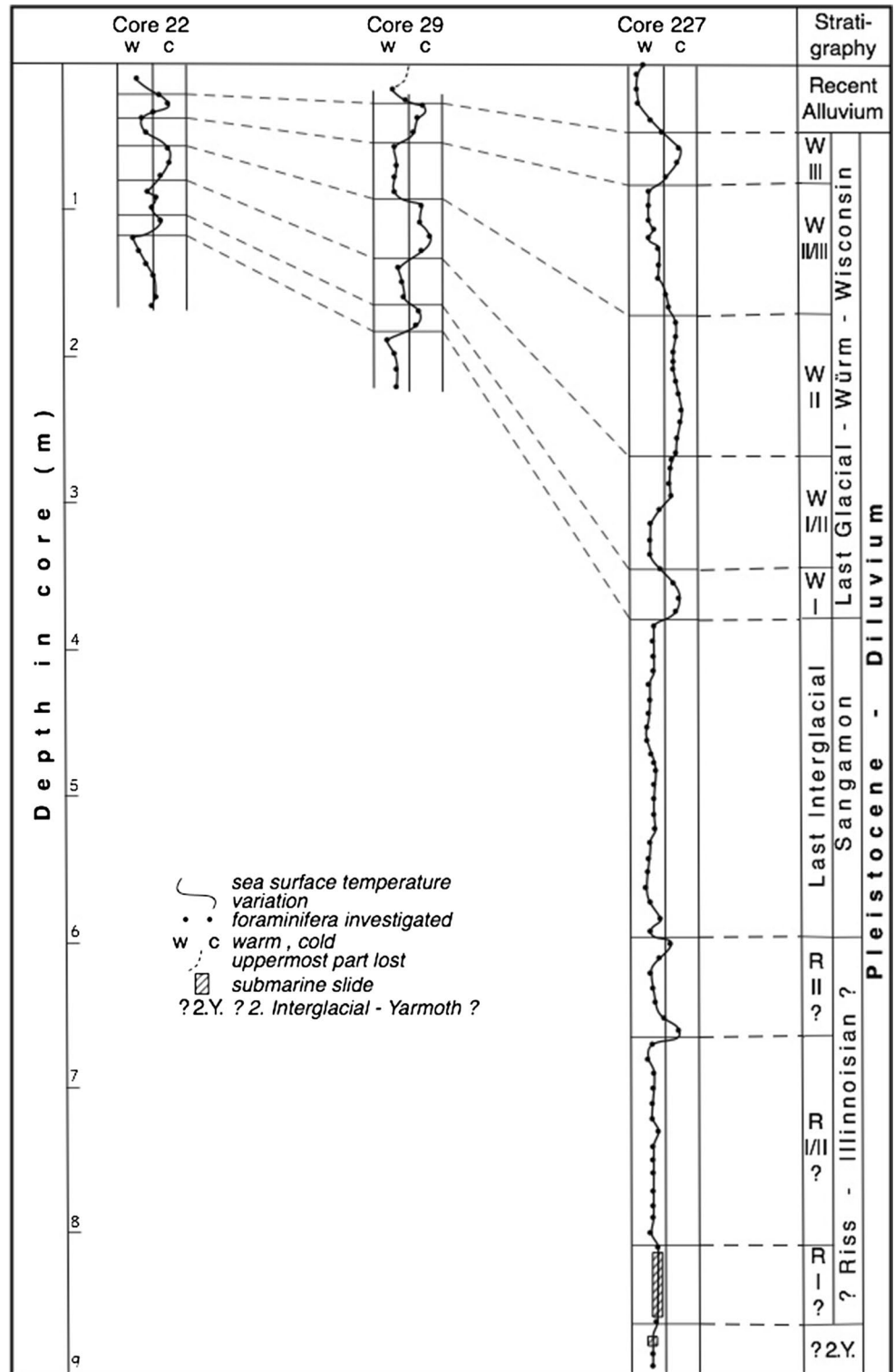


ice-rafted debris found during several expeditions outside the present drift ice boundary. With the end of the ice age, the convergence line retreated southward toward its present position. Due to the close relationship between the convergence line and the *Globigerina* ooze–diatom ooze boundary, the *Globigerina* ooze had to spread further south and transgress over the diatom ooze. Equally, the diatom ooze transgressed over the glacial debris as the latter retreated southward at the end of the Diluvium (glacial period). The spatial distribution of these present-day deep sea sediments is, therefore, a relatively young occurrence”. It was not until much later that this alternation of sediment patterns with

time was recognized to be the result of Milankovitch cycles driving climate.

These few lines demonstrate that Schott had already recognized the stratigraphic and facies importance of ice-rafted debris, features which were used decades later as time markers under the name of Heinrich events (Broecker et al. 1992). Once more far ahead of his time, Schott (1935:109) also recognized the importance of carbonate saturation in the conservation of the tiny carbonaceous tests of foraminifera and that their absence in the sediments did not inevitably mean that they were absent in the surface water at that time. “To summarize, we may say that the

Fig. 4 Stratigraphy of deep sea cores off W Africa derived from the ALBATROS expedition. Redrawn after Schott (1952)



spatial distribution of pelagic foraminifera on the sea floor predominantly depends on their regional distribution in the water volume as well as on the different dissolution rates of their carbonate tests, hence on two factors, of which one may impact more on distinct species. The assemblage

of dead pelagic foraminifera on the sea floor corresponds, therefore, only in a limited way to that living in the overlying watermasses” (Fig. 3). It took more that 30 years before Ruddiman and Heezen (1967) analyzed this relationship in the deep Atlantic in detail for the first time.

The quantitative working method of Schott also led him to study the sedimentation rates of distinct sediments and their differences in the global ocean. He wrote (1938a:326): “The depositional rate of the Globigerina ooze in the southern Indian Ocean is half of the rate in the equatorial Atlantic, where 1.2 cm of Globigerina ooze were deposited in 1000 years.”

His participation in the analysis of the Swedish ALBATROS expedition gave him immense satisfaction, since the application of the so-called Kullenberg corer allowed longer sediment cores to be retrieved, enabling a longer view back in time. He reported (1952:24f): “The distribution as well as the composition of the foraminifera fauna on the present day sea floor is known in the area of the investigated cores and can largely be explained. Therefore, it is possible to determine, from the modification of the percentage composition of the foraminifera fauna, whether different sediment layers contain a warm fauna, one almost equivalent to the present day composition or contain a temperate to cool fauna with respect to the region.” He continued (1952:27): “Based on these two observations it is not possible that the rhythmic fluctuations of sea surface temperature which are documented in these three cores are the result of local disturbances of the sea surface water. Instead they must result ultimately from larger climatic changes within the entire atmosphere of the globe; that means that the observed temperature fluctuations of the sea surface water during the sedimentation of the retrieved core material reflect the climate changes of warm periods (Alluvium) and ice ages (Diluvium), hence the youngest part of the geologic past (Fig. 4). In this way, the biostratigraphic division of the sediment cores from the deep sea floor can be brought into harmony with the generally accepted stratigraphical sequence of the Quaternary and so interpreted.”

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