Introduction

PREFACE

At the suggestion of Professor Dr. J. CADISCH, from 1943 to 1946 I chose to investigate the geology of the area of Arosa (Grisons, Switzerland) as a subject for my thesis. As a result of Professor CADISCH's inspiring guidance I directed most of my field and laboratory work towards a comprehensive study of the radiolarian chert-ophiolite problem not only in the Arosa area, but in other parts of the Swiss Alps as well. From 1953–1956 I made a further effort to gain a better understanding of the chert problem in the Central Alps, and once again Professor CADISCH gave me his valuable advice and rendered me every help possible to facilitate materially my investigations. – When I was requested to contribute an article to an Eclogae volume in honour of Professor CADISCH's 70th birthday, I accepted gladly and decided immediately to prepare an article on the regional aspects of the radiolarian chert problem. Although I am aware that I have no original contribution to offer, I thought it would be useful to compile data from literature on the world-wide occurrence of radiolarian cherts and associated rocks, and discuss the implications of such a comprehensive review. Field excursions in ophiolite-radiolarite areas of California, Turkey, Iran, Oman and Portuguese Timor have enabled me to add a few personal observations and remarks.

I owe a great debt of gratitude to Professor CADISCH, who first stimulated my interest in the chert problem. I also wish to express my sincere thanks to the BATAAFSE INTERNATIONALE PETROLEUM MAATSCHAPPIJ N.V., The Hague, for permission to publish the present article, to my colleagues who have contributed to the present study by supplying published reference and personal experience, and to Mr. E. G. EVERETT for critically reviewing the manuscript.

1. Introduction

The frequent association of radiolarian cherts, red shales, pelagic limestones and clastics on the one hand with peridotites, serpentinites, gabbros, diabases, spilitic pillow lavas and their metamorphic equivalents on the other hand, has been recognised and described in literature for more than 80 years: PANTANELLI (1880) and LOTTI (1886) probably gave the first explanation of chert-ophiolite relationships. MOLENGRAAFF (1900) incorporated under the name of Danau Formation a variety of rocks ranging from diabase-tuff, diabase, and diabase-porphyrite to quartzite, chert, clay-slate, and sandstone, which he saw for the first time typically developed in the area of the great lakes in Central Borneo. DAVIS (1918) in his classical work on the radiolarian cherts of the Franciscan Group in California devoted a full chapter to the occurrenc of radiolarian cherts and related rocks in many parts of the world. STEINMANN (1905, 1927) emphasised the frequent association of ophiolites with cherts from the Mediterranean mountain chains. Many more contributions of a general nature were made by a great number of authors, among which should be mentioned TALIAFERRO (1933), BRAMLETTE (1946), ROUTHIER (1946), GRUNAU (1947), WENK (1949), CORNELIUS (1951), CADISCH (1953), KÜNDIG (1956), CONTI (1958), GANSSER (1959), IRELAND (1959), KÜNDIG (1959), GRUNAU (1959), and TRÜMPY (1960). Strangely enough, no effort has ever been made before to put the observations from many parts of the world together in order to arrive

at a broad view of the complex aspects of the chert problem. The present article, therefore, aims at compiling some of the known facts, especially on age, lithology, palaeontology, and thickness of radiolarian cherts and associated sediments, and age of the ophiolites, on a world-wide scale. No claim, however, is made to complete coverage.

A world-wide review and its graphic presentation is considered a prerequisite to clarify some typical environmental and genetic relationships of the radiolarian chert association. In the main the following specific problems will be considered: Basin configuration and bathymetry – Pre-orogenic basin history – Time relationship between cherts, associated sediments and ophiolites based on palaeontological and other critical evidence – Post-orogenic tectonic position and structural style – The role of coarse clastics and turbidites – Origin of silica and ferric iron, also in relation to climatic belts – Origin of ferrous iron in relation to ophiolites – Chert-limestone sedimentation and possible ophiolitic influence – Chert stratification – Red and green colour.

The literature on cherts is of an uneven quality. It is not too often that a factual account is found on lithology, thickness, palaeontology and field relationship of radiolarian cherts and associated rocks. This may, of course, be due to one of a number of reasons. Many chert occurrences are found in virgin forests (as for example in Borneo, Celebes, Ceram, Timor, Guatemala, Colombia), where only scanty observations are possible. In addition, some of these areas have only been visited by petroleum geologists, whose attention was directed towards oil-geological problems and not to radiolarian rocks. Other well-exposed areas such as southern Iran and Oman are not easily accessible to earth scientists not concerned with petroleum operations and have, therefore, only been looked at superficially. The Mediterranean regions, the Alps and the Coast range of California, however, are the areas which have been studied in some detail. In this connection the very valuable work done by BLUMENTHAL (1963) and NEBERT (1959) in Turkey, and DUBERTRET (1953) in south-eastern Turkey and Syria should also be mentioned.

The interpretation of field observations in areas where radiolarian cherts and associated rocks are exposed, is by no means easy. The geological history of eugeosynclinal basins in which ophiolitic intrusions and extrusions frequently occur, is very complex (KÜNDIG, 1956, 1959). In addition, the rock content of these basins was subjected to a considerable amount of vertical uplift and tectonisation during major orogenic phases, which has made original complex relationships even more enigmatic due to incompetent folding, overthrust and gravity sliding phenomena. The factual statements, gaps in knowledge, theories and speculations offered in this article have to be regarded in this context.

2. Radiolarian Cherts and Associated Rocks in Space and Time, a World-Wide Review

The following is a brief and mainly factual account on world-wide occurrences of radiolarian cherts and associated rocks and their stratigraphic position. The principal facts are summarized in Plate I, and the text is restricted to a few supplementary remarks. Eugeosynclinal sediments are discussed, and only occasional mention is made of radiolarian rocks of other origin.