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Preface

An introduction to geosphere–biosphere coupling; cold seep related carbonate and mound formation and ecology

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A special session 'Geosphere–biosphere coupling; cold seep related carbonate and mound formation and ecology' was held at the AGU Fall conference in December 2000, and attracted considerable attention. A total of 17 oral presentations were given and some 30 posters were presented. This session followed up on discussions which have taken place in the scientific community over the past few years, regarding the role and importance of hydrocarbon seepage and hydrate dissociation in the formation of recently discovered, spectacular modern carbonate and mud mounds along the continental margins of the America, Africa, Asia and Europe. These buildups provide an outstanding opportunity to study the processes involved in their formation and provide a challenge in attempting to better understand the coupling between the deep geosphere and the biosphere.

Carbonate mounds were prominent reef types during Earth history since Cambrian times and these mounds may form giant host rocks for hydrocarbon accumulation. Carbonate mounds from the geological record provide ample evidence of microbial mediation in mound build-up and stabilisation. Some also suggest an initial control by fluid venting. Advanced models for some Palaeozoic mounds argue for the prominent role which biofilms may have played at the interface between the fluid and mineral phases. While up to the early 1990s there was little evidence of mud-mound formation from Late Cretaceous times onwards, recent investigations have increasingly reported occurrences of large mound clusters on modern ocean margins, in particular in basins rich in hydrocarbons. We should realise that mound provinces are significant ocean margin systems, up to now largely overlooked. How do such recent mound provinces relate to the fossil examples, what was and is the role and impact of fluid venting on the genesis of large mounds, and do the modern mound provinces provide a new window on the microbiota that were instrumental in building giant mounds throughout Phanerozoic times? These are burning questions, and the answers will only come through a new and continuous dialogue between experts of the past, explorers of the recent ocean, biologists and microbiologists.

Our present-day knowledge of reef growth and reef formation is limited to the relatively shallow water reef environments of the tropical regions and to a few observations of 'reefs' from the cool water coral margin off Europe; however,

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data on modern deep water carbonate mounds are extremely scarce if not entirely missing.

Modern mounds may be over 300 m high and many of them are made up of carbonate, although mud mounds do as well coexist in almost the same setting. In particular seabed and subseabed mounds of strongly different dimensions, and therefore of possibly different origin and controlled by different formation processes, are recognised along the American, African, Asian and European continental margins. These largely biogenic accumulations are for the most part located within the depth range of the habitable zone of deep water corals and appear to support an extremely rich deep water reef ecosystem.

A comprehensive explanation for their yet poorly documented and regionally studied distribution, shape, composition and formation in relation to the acoustic, seismic and sedimentary characteristics of the margins and a relationship to the locally extant oceanographic conditions is not as yet available. The acceptance of a simple model of mound formation is unsatisfactory because of the observed variation in size, morphology and the prolific number of mounds with their sometimes very localised clustering.

It is plausible to assume that seepage of hydrocarbons, as manifested and documented in carbonates, biota and microbia, plays an important role, although a link with fluid expulsion from depth is still poorly understood. However, as present-day mound provinces occur mostly at or near areas of increased exploration for hydrocarbons, there is an obvious need to better understand their occurrence, origin and possible relationship to cold seepage or hydrocarbon leakage, as well as to establish their potential impact on seabed stability and relationship to external forcing mechanisms.

The latter objectives form the foci of present research along the European Atlantic margin, supported by the EU through funding of the projects ACES (Atlantic Coral Ecology Studies), ECOMOUND (External Controls on Mound Formation) and GEOmound (Geological Controls on Mound Formation).

In this volume a number of contributions are included which deal with aspects of the above, and which were submitted for publication after the AGU session in San Francisco, December 2000. Four publications deal with aspects of recently discovered mounds in the Porcupine Bight and along the SE and SW Rockall Trough, along the Irish NE Atlantic Ocean margin. Two papers deal with Gulf of Mexico mounds and cold seepage, and two other papers provide results of in situ and laboratory experiments related to hydrate seepage.

The paper of Huvenne et al. provides a detailed 3D seismic study of the morphology and spatial distribution of buried mounds in the Porcupine Basin, and establishes a relationship of mound shape and distribution with tidally reversing currents. A clear and unambiguous relationship with the underlying strata, which could provide or deny a possible link to hydrocarbon seepage or gas hydrate dissociation, could, however, not be established. Beyer et al. present a detailed bathymetric map of the eastern slope of the Porcupine Bight, covering a part of the mound area, and relate acoustic backscatter to seabed properties. O'Reilly and co-authors describe effects of strong bottom currents on mounds of the SE Rockall Trough margin, based on TOBI deep towed sidescan sonar interpretations, and present a model for mound development. Van Weering and colleagues discuss new seismic data of giant carbonate mounds and their cold water coral cover on either margin of the Rockall Trough. Two possible stages of mound formation are recognised, the first of possible Early Tertiary age and a more recent one of late Early Pliocene to Recent age. No link could be established to hydrocarbon seepage or to hydrate dissociation.

The above papers contrast with the contribution by Hovland and Risk, who present an updated version and support for the 'hydraulic theory', which aims to relate the presence of specific benthic communities such as cold water corals or reefs of cold water corals to seepage of hydrocarbons from below.

The contributions by Sager et al. and by McDonald et al. give results and effects of a decade of detailed research on mound developments in the Gulf of Mexico while here a clear relationship to hydrate dissociation and hydrocarbon seepage is provided. Ample evidence for support of the hydraulic theory is presented, which so far is lacking in the Norwegian and European studies. McDonald et al. provide a highly detailed picture of biota and chemosynthetic communities developing in a series of detailed study areas, providing direct proof of the importance of geosphere–biosphere coupling in this area.

The contributions by Carson et al. include results of a number of in situ experiments to measure rates and effects of methane flow in a fault in ODP site 892-B, and of the effects of methanotrophic bacteria. Finally, Riestenberg and co-authors describe an experimental setting and results of hydrate dissociation in colloidal suspensions.

The guest editors believe that the papers included in this volume provide an excellent overview of major papers presented in the special AGU session and offer exciting insight into recent advances made in the rapidly developing field of geosphere–biosphere coupling. We are grateful to the many reviewers who contributed to this volume by refereeing the contributions submitted, and who provided the necessary critical and balanced comments.