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Economic and Palaeoceanographic Significance of Contourite Deposits

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Preface

The sunny summer of 2004 in Florence, Italy, witnessed the meeting of more than 50 people from academia and industry to discuss their ideas about the fascinating but still controversial world of contourites and bottom-current dominated sedimentary environments. Speeches and posters from different stratigraphic, bathymetric and geographical contexts were passionately presented. A panel discussion, carried out after the oral presentations, suggested some future trends in contourites research. Among the most important items suggested were the economic importance of contourite deposits and their stratigraphic–palaeoceanographic relationships.

The growing interest provoked by such themes, previously expressed by the editorial success of the Geological Society Memoir 22 (Deep-Water Contourites: Modern Drifts and Ancient Series, Seismic and Sedimentary Characteristics) edited by Stow et al. in 2002, was confirmed by the great number of participants in the General Symposium on Contourites held in Florence, 2004, during the 32nd International Geological Congress.

The study of the contourite deposits requires the application of many different theoretical, experimental and empirical resources provided by geophysics, sedimentology, geochemistry, experimental petrology, structural geology, scale modelling and field geology. Following this philosophy, we have edited this volume with the aim of providing an integrated approach for the study of the relevant contourite-related themes highlighted in the Florence meeting: their economic interest and palaeoceanographic implications. Our additional intention in editing this volume is to widen the understanding of the physical mechanisms involved in the sedimentation from contour currents, to better predict and evaluate their role in deposition.

This volume is composed of 16 papers broadly subdivided into two major categories (economic interest and stratigraphic–palaeoceanographic significance), with some of the papers lying between these two research areas. The last paper is dedicated to numerical simulations of contour currents and their impact on sedimentation.

The first five papers have strong economic appeal. Viana et al. discuss the main aspects of economic interest of contourite deposits, most of them related to the elements of petroleum systems. Modern and ancient cases are retrieved from international literature and presented under this new approach. Some new examples from the SE Brazil margin are presented for the first time, including 3D seismic, core and borehole data.

The contourite sand-rich channels from the North Atlantic described by Akhmetzhanov et al. constitute very important and well-documented examples of sediment accumulations with large and unexploited potential as reservoir rocks. Similarities to and distinctions from turbidite channels are also addressed.

Llave et al. provide us with a discussion on the Quaternary evolution of the contourite depositional system (CDS) in the Gulf of Cadiz based on morphological, structural and stratigraphic analyses using high-resolution seismic lines, borehole data and shallow coring data. Erosion-dominated episodes are contrasted with depositional ones as well as the distribution of coarse-grained versus fine-grained deposits, offering a very detailed temporal and spatial distribution of the various depositional elements that constitute a CDS.

Moraes et al. focus on an early Cenozoic case from the Campos Basin. They describe the presence of turbidite beds, reworked by bottom currents and interbedded with sandstones, and discuss their impact in the appraisal of a deep-water oilfield. The authors present a distinction between the classical turbidites, which constitute excellent reservoirs in the study case, and current-reworked sandstones that locally act as reservoir baffles or barriers.

Acting as a link between the first part of this volume, mostly dedicated to the papers that present relevant economic aspects, and the second part, in which discussions on the stratigraphic and palaeoceanographic aspects of contourite systems prevail, Rebesco et al. distinguish between contourites and turbidites based on swath bathymetry data recently acquired on Drift 7 off the Antarctica Peninsula. The authors discuss the coexistence of different sedimentary processes involving gravity flows and oceanic bottom currents expressed in the resultant sea-floor morphology and sediment accumulation characteristics.

The stratigraphic–palaeoceanographic papers are arranged in two sections. The first section consists of examples of Cenozoic to Quaternary contourites ordered geographically as a ‘world ocean tour’, beginning on the Pacific margin of the Antarctica Peninsula and continuing across the western and eastern Pacific, then to the southwestern Atlantic and finally ending with the Mediterranean and NW Atlantic. The second section includes three fossil cases, ordered from...
the most recent (Late Cretaceous) to the oldest (Palaeozoic).

The first paper of the stratigraphic–palaeoceanographic part is by Lucchi & Rebesco and discusses the palaeoenvironmental and palaeoclimatic conditions for the deposition of glacial contourites along most of the Antarctic margin. Such deposits constitute atypically non-bioturbated, ice-rafted debris rich layers and the authors propose to use them as proxies to define temporal and spatial extension of the Antarctic sea-ice. Such facies coexist with other sediment types and are predominantly derived from sediment-rich gravity flows.

Carter discusses the Canterbury Drifts, SW Pacific Ocean, which were deposited since the Oligocene. The author bases his study on the analysis of data derived from outcrops, marine seismic survey, coring and imaging, and borehole data. The emphasis is on the role of intermediate-depth currents in continental shelf–slope accretion. This approach builds on the hypothesis that slope currents interact with terrigenous derived sediments and the resultant deposit is a slope wedge formed by the welding of slope plastered drifts and the shelf–slope prograding clinoforms. Such a mechanism is probably present worldwide and its importance could be underestimated as a sedimentary process constructing continental margins.

Robinson et al. discuss the impact of glacial–interglacial modifications in the behaviour of the California Counter Current along the California Borderland on the sedimentary record. The authors report a decrease in the intensity of bottom reworking from late Marine Isotope Stage 5 (MIS 5) to the Holocene, expressed in variations in the grain size of associated deposits and in the degree of bioturbation. These observations indicate that sediment transport by bottom currents is not restricted to the western boundary currents but may also be the product of the action of bottom currents on eastern boundary slopes.

Duarte & Viana present a new Cenozoic drift system occurring in the SW Atlantic Ocean. The Santos Drift System is studied using industrial 3D and 2D seismic and borehole data. The authors identify two major drift complexes, a slope plastered drift and a separated drift, and establish their stratigraphic organization related to glacioeustatic curves and to major climatic–palaeoceanographic events. The study indicates that periods of relative high sea level correspond to phases of increasing drift thickening whereas during predominant lowstands slope drift sedimentation is reduced.

Verdicchio et al. deal with the bottom-current deposits along the southwestern Adriatic Margin, Mediterranean Sea. Using high-resolution seafloor imaging and sub-bottom profiling coupled with piston core analysis, the authors study the dramatic palaeogeographical and palaeoceanographic rearrangements that occurred in the Adriatic during the Late Quaternary sea-level oscillations and the depositional response to those modifications.

From the Northern Atlantic, the paper by Van Rooij et al. discusses the close association of small, mounded contourite drifts and cold-water coral banks, observed along the Porcupine Seabight. The authors propose that the different characteristics of the coral banks development are directly related to climate-driven modifications of the slope current regime and its interaction with tides and slope physiography.

The last paper of this part of the volume presents the Eirik Drift as a long-term barometer of the North Atlantic deepwater flux south of the Greenland margin. Hunter et al., using seismic stratigraphic techniques, report that the Eirik Drift contains an expanded sedimentary record of bottom and intermediate current intensity variation ranging from the Early Eocene to the Holocene. The authors note that variations in current strength on a decadal to millennial time scale can be related to changes in thermohaline circulation and climate, with a number of internal discontinuities reflecting a variety of palaeoceanographic events.

The next three papers deal with ancient contourite systems ranging from Mesozoic to Palaeozoic ages. Esmerode et al. propose that the flooding of the NW European craton during the Late Cretaceous trangression created relatively deep epeiric seas into which the oceanographic conditions that prevail on continental margins extended. Such starved basins, instead of presenting flat-lying pelagic successions, are marked by the sedimentary record of the action of strong bottom currents that developed a multitude of imprints on the chalk deposits, such as sediment waves, drifts, moats and extensive unconformities. The authors identified two major episodes of drift deposition in the Danish Basin, one in the Santonian to Campanian and one in the Maastrichtian, developed by the northwestward flow of contour currents.

Georgiev & Botoucharov use borehole data, cores and industry seismic data to present the possibility that a middle Jurassic interbedding of shales and siltstones occurring in the South Moesian platform (Bulgaria) constitutes the sedimentary record of bottom-current processes. The structurally controlled palaeophysiography would have strongly influenced the bottom circulation and hence sediment deposition.

Detailed outcrop studies coupled with palaeogeographical reconstruction lead Hünke to propose that the Devonian calcareous bioclastic successions observed in Germany, Morocco, Austria and
Italy preserve facies characteristics corresponding to contourites. The author observes that the widespread current-induced reworking of calcareous sediments, phosphate formation and major erosion-related hiatuses are associated with major palaeocirculation events that would have occurred as a result of the acceleration of thermohaline currents accompanying the narrowing of the oceanic passageway between the approaching Laurussia and Gondwana continents during the middle and late Devonian.

This volume is completed by a paper by Lima et al. in which a hydrodynamic numerical model is proposed to study the behaviour of bottom currents flowing along a submarine canyon and adjacent open slope and shelf edge, and their interaction with sediment-rich turbidity currents flowing down-canyon. The model describes the importance of differing current-forcing mechanisms, and estimates their resultant sediment transport under the combined action of turbidity and bottom currents. The editors agree that this approach, as much as physical modelling, is useful to better quantify the impact of bottom currents among the diversity of sedimentary processes occurring in the deep ocean. This may lead to a wider understanding of the role of bottom currents in the geological record and reduce the gap between the different techniques used in earth and oceanic sciences.

No publication can achieve a good scientific standard without the tremendous dedication of the authors and coauthors of the contributions. To all of them we would like to express our deep acknowledgement. Also of huge importance was the role performed by the reviewers, who realized the difficulties of the authors, who may sometimes be too deeply involved with their own data. The reviewers deserve our greatest recognition; they are A. Akhmetzhanov; A. Bouma; A. Carmelenghi; M. Carminatti; S. Ceramicola; E. Cowan; B. de Mol; C. Escutia Dotti; D. Evans; J.-C. Faugères; E. Gonthier; J. Howe; B. Kuvaas; J.-S. Laberg; P. Magalhães; E. Mutti; W. Normark; D. Piper; M. Roveri; I. Soares; G. Stampfli; D. Stow; F. Surlyk; G. Uenzelmann; J. Veevers. Angharad Hills, Commissioning Editor of the Geological Society Publishing House, invited the conveners of the symposium in Florence to edit this Special Publication for the Geological Society of London. Thanks to her and to her continuous and friendly support, we have shared a heavy but pleasant task during this last year and a half.

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Adriano R. Viana
Michele Rebesco
April 2006

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