Developments in Sedimentology, 58

HEAVY MINERALS IN USE

Edited by

MARIA A. MANGE

Department of Geology University of California, Davis, CA USA

DAVID T. WRIGHT

Department of Geology University of Leicester UK

١



Amsterdam ● Boston ● Heidelberg ● London, ● New York ● Oxford Paris ● San Diego ● San Francisco ● Singapore ● Sydney ● Tokyo

LIST OF CONTENTS

Contributing Authors	xiii
Foreword	xix
Preface	xxi
Acknowledgements.	XXV
Introduction and Overview	xxvii

PART I: HEAVY MINERALS IN THE STUDY OF SILICICLASTIC SEDIMENTS: PRINCIPLES, PROCESSES AND PRODUCTS

1.1 Entrainment, Transport and Deposition: Hydraulic Control

Chapter 1.	The Entrainment, Transport and Sorting of Heavy Minerals by Waves and Currents <i>Paul D. Komar</i>	3
Chapter 2.	The Nile Delta: Processes of Heavy Mineral Sorting and Depositional Patterns	49
Chapter 3.	The Sources and Hydraulic Sorting of Heavy Minerals on the Northern Portuguese Continental Margin	75
	João Cascalho and Catarina Fradique	
	1.2 From Surface Weathering to Burial Diagenesis	

Chapter 4.	Surface Textures and Dissolution Processes of Heavy Minerals in the Sedimentary	
	Cycle: Examples from Pyroxenes and Amphiboles	113
	Michael Anthony Velhel /	

List	of	Contents

Chapter 5.	Provenance and Palaeoenvironmental Interpretation of Superficial Deposits, with Particular Reference to Post-Depositional Modification of Heavy Mineral Assemblages	151
Chapter 6.	'In situ' Dissolution of Heavy Minerals Through Extreme Weathering, and the Application of the Surviving Assemblages and their Dissolution Characteristics to Correlation of Dutch and German Silver Sands	189
Chapter 7.	Stability of Detrital Heavy Minerals During Burial Diagenesis	-215
Chapter 8.	Provenance and Diagenesis of Heavy Minerals, Cenozoic Units of the Northwestern Gulf of Mexico Sedimentary Basin	247
Chapter 9.	Effects of Hydrothermal Fluids on the Heavy Mineral Assemblage of a Late Pleistocene Succession Deposited in an Oceanic Ridge Valley (Escanaba Trough, Juan de Fuca Plate)	263
Chapter 10.	Alteration of Opaque Heavy Minerals as a Reflection of the Geochemical Conditions in Depositional and Diagenetic Environments Rikke Weibel and Henrik Friis	277

1.3 Heavy Minerals and Grain Size

Chapter 11.	An Integrated Grain-Size and Heavy Mineral Analysis of the Palaeocene Strata of the London Basin	307
Chapter 12.	Heavy Minerals in Shales	323

1.4 Miscellaneous Techniques

Chapter 13.	Geochemistry of Heavy Minerals	345
	Maria A. Mange and Andrew C. Morton	
Chapter 14.	The Effects of Burial Diagenesis on Detrital Heavy Mineral Grain Surface Textures	393
	Grenville Turner and Andrew C. Morton	

List of Contents

Chapter 15.	Scanning Electron Microscopy of Garnet from Southern Michigan Soils: Etching Rates and Inheritance of Pre-Glacial and Pre-Pedogenic Grain-Surface Textures	413
Chapter 16.	High-Resolution Heavy Mineral Analysis (HRHMA): A Brief Summary Maria A. Mange and David T. Wright	433
	1.5 Numerical Data Analysis	
Chapter 17.	Multivariate Analysis of Heavy Mineral Assemblages of Sediments from the Marginal Seas of the Western Pacific	439
Chapter 18.	Statistical Analysis of High-Resolution Heavy Mineral Stratigraphic Data from the Ordovician of Western Ireland and its Tectonic Consequences	465

Chapter 19.	Evolution of Quaternary to Modern Fluvial Network in the Mid-Hungarian	
	Plain, Indicated by Heavy Mineral Distributions and Statistical Analysis of	
	Heavy Mineral Data	491
	Edit Thamó-Bozsó and Lajos Ó. Kovács	

Paul D. Ryan, Maria A. Mange and John F. Dewey

PART II: PROVENANCE, TRANSPORT, DEPOSITION, EXHUMATION

2.1 Regional Studies—Modern and Ancient Environments

Chapter 20.	Heavy Mineral Concentration in Modern Sands: Implications for Provenance Interpretation	517
Chapter 21.	The Rivers of Southeast Ireland and the Sands of the Irish Sea: Heavy Minerals Show that Proximity does not Always Predetermine Provenance	547
Chapter 22.	Sediment Trails in Tectonically Active Islands: Heavy Minerals in use in New Zealand	569

List of Contents

١

Chapter 23.	Heavy-Mineral Provenance in an Estuarine Environment, Willapa Bay, Washington, USA: Palaeogeographic Implications and Estuarine Evolution	587
Chapter 24.	Interpretation of Quaternary Tectonic and Environmental Change Using Heavy Minerals of the Yangtze Delta Plain Jill S. Schneiderman and Zhongyuan Chen	607
Chapter 25.	Heavy-Mineral Associations as Tracers of Limited Compositional Mixing During Turbiditic Sedimentation of the Marnoso-Arenacea Formation (Miocene, Northern Apennines, Italy) Giorgio Gandolfi, Luigi Paganelli and William Cavazza	621
Chapter 26.	Distribution Pattern and Provenance Implications of the Heavy Minerals in Neoproterozoic to Mesozoic Siliciclastic Successions in the Arabo-Nubian Shield and its Northern Periphery: A Review	647
Chapter 27.	The Use of Heavy Minerals in the Reconstruction of Ice-Sheet Drainage Patterns: An Example from the Edge of the East Antarctic Ice Sheet	677
Chapter 28.	Heavy and Light Mineral Fractions Indicate Polygenesis of Extensive Terra Rossa Soils in Istria, Croatia	701
	2.2 Tectonogenic Sediments: The Use of Heavy Minerals in Active Geodynamic Settings	
Chapter 29.	Plate Tectonics and Heavy Mineral Suites of Modern Sands Eduardo Garzanti and Sergio Andò	741
Chapter 30.	Provenance of Flysch Sediments and the Palaeogene-Early Miocene Geodynamic Evolution of the Hellenides: A Contribution from Heavy Mineral Investigations	765 <u></u>
Chapter 31.	The Use of Heavy Minerals in Determining the Provenance and Tectonic Evolution of Mesozoic and Caenozoic Sedimentary Basins in the Continent-Pacific Ocean Transition Zone: Examples from Sikhote-Alin and Koryak-Kamchatka Regions (Russian Far East) and Western Pacific	789

viii

Chapter 32.	Heavy Mineral Constraints on the Provenance of Cenozoic Sediments	
	from the Foreland Basins of Assam and Bangladesh: Erosional History	
	of the Eastern Himalayas and the Indo-Burman Ranges	823
	Ashraf Uddin, Pranav Kumar, Jogen N. Sarma and Syed H. Akhter	

PART III: INTEGRATED AND INTERDISCIPLINARY HEAVY MINERAL APPLICATIONS

3.1 Heavy Mineral Studies Integrated with Other Geoanalytical Techniques

Chapter 33.	Heavy Minerals and Detrital Fission-Track Thermochronology			
Chapter 34.	 Heavy Minerals in the Subsurface: Tracking Sediment Sources in Three Dimensions D. Johannes Huisman and Gerard Th. Klaver 			
Chapter 35.	Heavy Minerals in the Swiss Molasse Basin: Occurrence, Frequency, Chemistry and Thermochronology Hilmar von Eynatten	887		
Chapter 36.	Evolution of the Amazon Basin in Ecuador with Special Reference to Hinterland Tectonics: Data from Zircon Fission-Track and Heavy Mineral Analysis	907		
	3.2 The Use of Heavy Minerals in Interdisciplinary Research			
3.2.1 Fo	rensic Science—Evidence from Heavy Minerals in Criminal Investigati	on		
Chapter 37.	Heavy Minerals in Forensic Science	937		
Chapter 38.	Forensic use of Heavy Minerals in Civil and Criminal Investigations	963		
	3.2.2 Geoarchaeology			
Chapter 39.	Discriminating among Volcanic Temper Sands in Prehistoric Potsherds of Pacific Oceania using Heavy Minerals	985		

١

List of Contents

PART IV: INDUSTRIAL APPLICATIONS: RESERVOIR CHARACTERISATION, ECONOMIC HEAVY MINERAL DEPOSITS, DIAMOND PROSPECTING

4.1 Reservoir Characterisation

Chapter 41.	Correlation of Triassic Sandstones in the Strathmore Field, West of Shetland, Using Heavy Mineral Provenance Signatures	1037
Chapter 42.	High-Resolution Heavy Mineral- and Magnetostratigraphy; a Powerful Tool for Subdivision and Correlation of Barren Successions: An Example from the Sherwood Sandstone Group (Triassic) of the East Irish Sea Basin and Surrounding Areas Maria A. Mange, Peter Turner, David Ince and David T. Wright	1073
Chapter 43.	The Application of Bulk Rock Geochemistry to Reveal Heavy Mineral Sorting and Flow Units in Thick, Massive Gravity Flow Deposits, Siri Canyon Palaeocene Sandstones, Danish North Sea	、 1099
Chapter 44.	The Role of Heavy Mineral Analysis as a Geosteering Tool During Drilling of High-Angle Wells Andrew C. Morton	1123

4.2 Mineral Exploration and Mining

Chapter 45.	Heavy-Mineral Sands of the Atlantic and Gulf Coastal Plains, USA.	1145
	Fredric L. Pirkle, William A. Pirkle and E.C. Pirkle	

4.3 The Role of Upper Mantle Derived Heavy Minerals in Diamond Exploration

Chapter 46.	Diamonds and Associated Heavy Minerals in Kimberlite:	
	A Review of Key Concepts and Applications	1235
	Tom E. Nowicki, Rory O. Moore, John J. Gurney and Mike C. Baumgartner	

Х

Concluding Remarks			1269
Maria A. Mange and David T. Wright	*		
	, .	,	
Subject Index			1271