

Contents

Introduction	1
Acknowledgements	3
1. General Information on the Arabian Peninsula	4
1.1. Geology (R. W. CHAPMAN)	4
1.1.1. Introduction	4
1.1.2. Structure and Geologic History of the Peninsula	4
1.1.3. Arabian Shield	5
1.1.4. Arabian Shelf	9
1.1.5. Mobile Belt	15
1.1.6. Red Sea	16
1.1.7. Economic Geology	18
1.2. Geomorphology (R. W. CHAPMAN)	19
1.2. 1. Introduction	19
1.2. 2. Arabian Gulf Coastal Region	20
1.2. 3. As Summan Plateau	22
1.2. 4. Eolian Sand Areas	23
1.2. 5. Cuesta Region	25
1.2. 6. Central Plateau Region	26
1.2. 7. Mountains of Western Arabia	27
1.2. 8. Red Sea Coastal Plain	28
1.2. 9. Mountains of Southern Arabia	29
1.2.10. Oman Mountains	29
1.3. Climate (E. SCHYFSMA)	31
1.3.1. Introduction	31
1.3.2. Temperatures	33
1.3.3. Precipitation	37
1.3.4. Relative Humidities	39
1.3.5. Prevailing Wind Directions	42
1.3.6. Seasons	43
1.3.7. Solar Radiation	44
2. Regions of Investigation	45
2.1. Gulf Coastal Region and Its Hinterland	45
2.1.1. General Geology (D. H. JOHNSON)	45
2.1.1.1. Topography	45
2.1.1.2. Stratigraphy	45
2.1.1.3. Structure	50
2.1.1.4. Economic geology	50

2.1.2. Sea Level Fluctuations During the Quaternary Period (H. FELBER, H. HÖTZL, V. MAURIN, H. MOSER, W. RAUERT, J. G. ZÖTL)	50
2.1.2.1. Prewürmglacial sea level fluctuations	51
2.1.2.2. Sea level fluctuations during the Würm time	54
2.1.2.3. Holocene sea level fluctuations	56
2.1.3. Geologic History of the Al Hasa Area Since the Pliocene (H. HÖTZL, V. MAURIN, J. G. ZÖTL)	58
2.1.3.1. Terrestrial sedimentation of the Lower Pliocene	58
2.1.3.2. Pliocene-Pleistocene marine transgression and regression	59
2.1.3.3. Breakers terraces and caves of Jabal Al Qarah	63
2.1.3.4. The Pliocene/Pleistocene Delta of Wadi As Sah'ba	67
2.1.3.5. Quaternary erosion and sedimentation	70
2.1.3.6. Climatic and hydrologic conditions	74
2.1.4. Geomorphology of the Eastern Margin of the Shedgum Plateau (R. W. CHAPMAN)	77
2.1.4.1. Introduction	77
2.1.4.2. Factors controlling the geomorphogeny	78
2.1.4.3. Landforms	79
2.1.4.4. Calcareous duricrust	82
2.1.5. Sabkhahs of Eastern Saudi Arabia (D. H. JOHNSON, M. R. KAMAL, G. O. PIERSON, J. B. RAMSAY)	84
2.1.5.1. Introduction	84
2.1.5.2. Reconnaissance observations	86
2.1.5.3. Observations on Sabkhat Ar Riyas	87
2.1.5.4. Brine studies at Sabkhat Ar Riyas	91
2.1.6. Hydrochemical Investigations in the Areas of Al Qatif and Al Hasa With Some Remarks on Water Samples From Wadi Al Miyah and Wadi As Sah'ba Near Haradh (C. JOB)	93
2.1.6.1. Al Qatif oases	93
2.1.6.2. Al Hasa oasis	119
2.1.6.3. Wadi Al Miyah	127
2.1.6.4. Wadi As Sah'ba near Haradh	130
2.1.6.5. Final remarks	134
2.1.7. Cluster Analyses of Water Wells of the Al Qatif and Al Hasa Areas (R. J. BECKMAN, J. B. RAMSAY)	135
2.1.7.1. Introduction	135
2.1.7.2. Cluster analysis	136
2.1.7.3. Combined Al Hasa and Al Qatif areas	138
2.1.7.4. Al Hasa area	140
2.1.7.5. Al Qatif area	145
2.1.7.6. Discriminant analysis	148
2.1.7.7. Discussion	150
2.1.7.8. Appendix	151
2.1.8. Isotopic Composition of Waters of Al Qatif and Al Hasa Areas (H. MOSER, E. PAK, W. RAUERT, W. STICHLER, J. G. ZÖTL)	153
2.1.8.1. Introduction	153
2.1.8.2. Deuterium and oxygen-18	153
2.1.8.3. Tritium	156
2.1.8.4. Carbon-14	159
2.1.8.5. Sulfur-34	160
2.2. As Sulb Plateau	163
2.2.1. General Geology (E. SCHYFSMA)	163
2.2.2. Karstification and Geomorphogeny of As Sulb Plateau (H. FELBER, H. HÖTZL, H. MOSER, W. RAUERT, J. G. ZÖTL)	166

2.3. Wadi Ar Rimah	173
2.3.1. The Quaternary Development of the Upper Part of Wadi Ar Rimah (H. HÖTZL, H. FELBER, J. G. ZÖTL)	173
2.3.1.1. General remarks on wadi investigations	173
2.3.1.2. Geological conditions in the area of Wadi Ar Rimah	174
2.3.1.3. Geomorphological features	174
2.3.1.4. Quaternary sediments	178
2.3.1.5. The cycle of accumulation and erosion	181
2.3.2. Hydrogeological and Hydrochemical Investigations in the Upper Part of Wadi Ar Rimah (H. HÖTZL, C. JOB, H. MOSER, W. RAUERT, W. STICHLER)	182
2.3.2.1. Hydrogeological conditions in Wadi Ar Rimah between Aqlat As Suqr and 'Unayzah (H. HÖTZL)	182
2.3.2.2. Hydrochemical investigations and isotope measurements in the areas of Riyadh Al Khabra, Wadi Ar Rimah and Wadi Maraghan (C. JOB, H. MOSER, W. RAUERT, W. STICHLER)	187
2.4. Cuesta Region of the Tuwayq Mountains	194
2.4.1. General Geology and Stratigraphy (E. SCHYFSMA)	194
2.4.2. Accumulation Terraces of Wadi Hanifah and Wadi Al Luhy (H. HÖTZL, H. FELBER, V. MAURIN, J. G. ZÖTL)	202
2.4.2.1. Morphological and sedimentological features	202
2.4.2.2. Paleontological description of Gastropoda	205
2.4.2.3. Biogeographic and ecological aspects	208
2.4.3. Wadi Birk (H. HÖTZL, V. MAURIN)	209
2.4.3.1. Wadi deposits	209
2.4.3.2. Accumulation terrace in the area of Al Hawtah	213
2.4.3.3. Morphogeny of Wadi Birk	214
2.4.4. Chemistry and Isotope Content of Some Wadi Groundwaters in the Central Parts of the Tuwayq Mountains (C. JOB, H. MOSER, W. RAUERT, W. STICHLER)	216
2.4.4.1. Wadi Hanifah, Wadi Nisah, Wadi Al Luhy	216
2.4.4.2. Wadi Al Hawtah, Wadi Birk	222
2.4.4.3. The δD - $\delta^{18}\text{O}$ relation of waters in the central parts of the Tuwayq Mountains	224
2.5. Wadi Ad Dawasir and Its Hinterland	226
2.5.1. General Geology (H. HÖTZL)	228
2.5.2. Quaternary Studies on the Recharge Area Situated in Crystalline Rock Regions (H. HÖTZL, H. J. LIPPOLT, V. MAURIN, H. MOSER, W. RAUERT)	230
2.5.2.1. Wadi Ranyah between the villages of Al Amlah and Rawdhah . .	230
2.5.2.2. Age determination of basalt rocks and its significance in the reconstruction of climate conditions during the Quaternary	234
2.5.2.3. Ranyah-Bishah accumulation plain	236
2.5.2.4. Wadi Bishah's lower part	238
2.5.3. Studies of the Quaternary Development of the Eastern Part of the Recharge Area of Wadi Ad Dawasir (H. HÖTZL, V. MAURIN, J. G. ZÖTL)	239
2.5.3.1. The area between the oases of Al Khamasin and Al Lidam	239
2.5.3.2. The break-through in the Tuwayq Mountains	243
2.5.3.3. The wadi's transition into Ar Rub' Al Khali	244
2.5.4. Hydrochemical Investigations and Measurements of the Content of Isotopes of Wells in Wadi Ad Dawasir (C. JOB, H. MOSER, E. PAK, W. RAUERT, W. STICHLER)	246
2.6. Ar Rub' Al Khali (H. A. MCCLURE)	252
2.6.1. Introduction	252
2.6.2. Stratigraphy and Sedimentation	252
2.6.2.1. Geomorphic processes	256

2.6.2.2. Late Quaternary history	258
2.6.2.3. Late Pleistocene lakes	260
2.6.2.4. Holocene lakes	261
2.6.3. Paleoclimate	262
3. Summary and General Conclusions	264
3.1. Quaternary Sediments (H. HÖTZL, F. KRÄMER, V. MAURIN)	264
3.1.1. Scope of Investigations	264
3.1.2. Sedimentation in Wadis	265
3.1.2.1. General conditions of accumulation	265
3.1.2.2. Description of sediments	266
3.1.3. Sediments in the Area of Vast Accumulation Plains	277
3.1.3.1. Alluvial fans	277
3.1.3.2. Sand dunes	280
3.1.3.3. Lacustrine deposits	282
3.1.3.4. Duricrust	284
3.1.4. Marine Sediments and Sabkhae in the Coastal Region of the Arabian Gulf	290
3.1.5. Chronological and Stratigraphic Classification of Processes of Erosion and Sedimentation During the Quaternary	292
3.1.5.1. Development of the drainage system	292
3.1.5.2. Processes of marine transgressions	294
3.1.5.3. Age determination of the sequence of sediments	295
3.2. Climatic Changes During the Quaternary Period (H. HÖTZL, J. G. ZÖTL)	301
3.2.1. Holocene	301
3.2.2. Climatic Fluctuations During the Würm	303
3.2.3. Prewürm Pleistocene	305
3.2.4. Geochronological Delimitation and Division of the Quaternary	306
3.2.5. The Late Pliocene/Early Pleistocene Phase	310
References	312
Index of Geographical Names	331
Transcription of Names Used in Some Figures	335