

# THE RIVER NILE

*Geology, Hydrology and Utilization*

RUSHDI SAID

*Consulting Geologist, Ph.D. (Harvard),  
Dr. rer. nat. h.c. (Technical University, Berlin),  
Membre Institut d'Egypte, Honorary Fellow Geological Society of America,  
Honorary Member Geological Society of Africa*



PERGAMON PRESS

OXFORD · NEW YORK · SEOUL · TOKYO

# CONTENTS

Preface	ix
---------	----

## PART I: ORIGIN AND EVOLUTION OF THE RIVER NILE

Summary of Part One	1
1. Introduction	7
2. The Lake Plateau	12
3. The Sudd and the Central Sudan Basin	18
4. Rivers of the Ethiopian Highlands	21
4.1. <i>The Atbara</i>	24
4.2. <i>The Blue Nile</i>	24
4.3. <i>The Sobat</i>	27
5. The Nubian Nile; Transit from the Interior of Africa to the Mediterranean Sea	28
6. The Egyptian Nile	32
6.1. <i>The Early Egyptian Niles, From a Deep Canyon to a Graded River</i>	36
6.2. <i>The Prenile, An African Connection is Established</i>	41
6.3. <i>The Neonile, The African Connection Becomes Tenuous</i>	45
6.3.1. <i>The Early Paleolithic ephemeral streams and the intervening alpha Neonile</i>	47
6.3.2. <i>The early Middle Paleolithic erratic Nile</i>	49
6.3.3. <i>The late Middle Paleolithic and Late Paleolithic seasonal beta and gamma Neoniles</i>	50
6.3.4. <i>The modern river (delta Neonile)</i>	53
7. The Modern Landscape of the Floodplain of the Nile Valley, Delta and Fayum	57
7.1. <i>The Composition of the Modern Alluvium of the Valley and Delta</i>	57
7.2. <i>The Thickness of the Modern Alluvium of the Valley and Delta</i>	59
7.3. <i>The Floodplain of the Valley</i>	61
7.4. <i>The Delta</i>	68
7.4.1. <i>Evolution</i>	70
7.4.2. <i>Effect of sea level fluctuations</i>	76
7.5. <i>The Fayum</i>	78
8. Climate and the Evolution of the River	82
8.1. <i>Past Climatic Fluctuations</i>	85
8.1.1. <i>Glacial periods</i>	86
8.1.2. <i>Post-last glacial times</i>	88
8.2. <i>Forcing Factors and the Question of Periodicity</i>	89

## PART II: THE HYDROLOGY OF THE RIVER NILE

1. Introduction	95
2. Rhythm and Ritual of the Nile	96
3. In Search of the Sources of the Nile	102
4. The Amount of Water Carried by the Nile	108
4.1. <i>Jinja (Exit of Lake Victoria)</i>	111
4.2. <i>Paraa (Exit of Lake Kioga)</i>	113
4.3. <i>Panyango (Exit of Lake Albert)</i>	114
4.4. <i>Mongalla (Entrance of the Sudd, Upstream Bahr el-Gebel)</i>	114
4.5. <i>Malakal</i>	115
4.6. <i>Mogren</i>	117
4.7. <i>Khartoum</i>	119

4.8.	<i>Atbara K3</i>	119
5.	The Nile at Aswan	121
6.	Past Fluctuations of the Nile	127
6.1.	<i>The Holocene (Nabtian) Wet Phase</i>	128
6.2.	<i>Nile Fluctuations in Ancient Egypt</i>	133
6.2.1.	<i>Old Kingdom records (3050-2480 B.C.)</i>	134
6.2.2.	<i>The low Niles of the First Intermediate Period</i>	138
6.2.3.	<i>The Middle Kingdom Nile and the period of high floods (1840-1770 B.C.)</i>	143
6.2.4.	<i>Nile failures and economic decline, Dynasties XX and XXI (1200-945 B.C.)</i>	149
6.2.5.	<i>Nile level records at Kamak, Dynasties XXII-XXVI (945-525 B.C.)</i>	152
6.2.6.	<i>The Nile from 500 B.C. to 600 A.D.</i>	152
6.3.	<i>Nile Fluctuations in Medieval Egypt (The Roda Nilometer)</i>	155
6.3.1.	<i>Sources of the records of the Roda Nilometer</i>	159
6.3.2.	<i>The records</i>	161
6.3.2.1.	<i>Period 640-930 A.D.</i>	164
6.3.2.2.	<i>Period 931-1090 A.D.</i>	164
6.3.2.3.	<i>Period 1090-1195 A.D.</i>	165
6.3.2.4.	<i>Period 1196-1350 A.D.</i>	165
6.3.2.5.	<i>Period 1351-1467 A.D.</i>	166
6.3.2.6.	<i>Period 1468-1510 A.D.</i>	166
6.3.2.7.	<i>Period 1511-1630 A.D.</i>	166
6.3.2.8.	<i>Period 1631-1840 A.D.</i>	168
7.	Concluding Remarks	170

### **PART III: THE UTILIZATION OF THE WATERS OF THE NILE**

1.	The Early Settlers Meet a Hostile River	175
2.	The River Becomes Beneficial; Agriculture comes to the Nile Valley	185
3.	Basin Irrigation	188
3.1.	<i>The Introduction of Lift Irrigation and the Reclamation of the Fayum Province</i>	193
3.2.	<i>Land Use in Ancient and Medieval Egypt</i>	200
3.3.	<i>Crops of the Basin Irrigation System</i>	205
3.4.	<i>The Population of Ancient and Medieval Egypt</i>	208
4.	Perennial Irrigation	213
4.1.	<i>Seasonal Storage Schemes</i>	214
4.2.	<i>Irrigated Agriculture comes to the Sudan</i>	219
4.3.	<i>Century (Over-year) Storage Schemes</i>	220
4.3.1.	<i>Upper Nile Century storage scheme</i>	221
4.3.1.1.	<i>Phase I of the Century storage scheme</i>	223
	(a) The equatorial lakes reservoirs	223
	(b) The Jonglei Canal	225
	(c) The Lake Tana Reservoir	227
	(d) The Fourth Cataract Dam	228
	(e) Amount of water stored	228
4.3.1.2.	<i>Phase II of the Century storage scheme</i>	228
4.3.2.	<i>The Aswan High Dam</i>	228
4.3.2.1.	<i>Historical</i>	228
4.3.2.2.	<i>The High Dam</i>	233
4.3.2.3.	<i>The reservoir</i>	234
4.3.2.4.	<i>The operation of the reservoir</i>	237
4.3.2.5.	<i>Benefits of the Aswan High Dam</i>	238
4.3.2.6.	<i>Side effects of the Aswan High Dam</i>	241

(a)	In the reservoir area	241
(b)	In the downstream river	245
i.	Channel degradation and silt deprivation	245
ii.	Dune accumulation	248
iii.	Coastal erosion	248
iv.	The increased use of pesticides and fertilizers	250
v.	Rise of the water table and the problems of drainage	251
vi.	Changes in water quality	253
4.4.	<i>Crops of the Perennial Irrigation System</i>	254

## **PART IV: THE FUTURE USES OF THE WATERS OF THE NILE**

1.	Agreements Pertaining to the Waters of the Nile	259
1.1.	<i>Historical</i>	259
1.2.	<i>The Agreements</i>	260
1.3.	<i>Agreements Between Egypt and the Sudan</i>	262
1.4.	<i>The Law of International Drainage Basins</i>	264
1.5.	<i>The Present State of the Nile Water Agreements</i>	265
2.	Present and Future Land and Water Use in the Nile Basin States	269
2.1.	<i>Egypt and the Master Water Plan</i>	271
2.1.1.	<i>The present use of water</i>	273
2.1.1.1.	<i>Domestic consumption</i>	274
2.1.1.2.	<i>Industrial consumption</i>	274
2.1.1.3.	<i>Non-consumptive use for inland navigation and hydropower generation</i>	274
2.1.1.4.	<i>Agricultural use (evapotranspiration)</i>	275
2.1.2.	<i>The future use of water</i>	278
2.2.	<i>The Sudan and the Future Use of the Waters of the Nile</i>	280
2.3.	<i>Ethiopia, Africa's Water Tower</i>	282
2.4.	<i>The Lacustrine States</i>	287
3.	Concluding Remarks	290

## **APPENDIX: REFERENCES**

## **INDICES**