Chapter 1
Introduction

The main objective of this book is to trigger a fact finding effort and an interdisciplinary approach to the role of groundwater base-levels in hydrogeological systems due to their different configurations and their changes in time and space.

The term "base-level" is usually related to surface water drainage systems and erosion processes. Several definitions exist to this term in the literature, one of which is "The lowest level to which a land surface can be reduced by the action of running water". In general, the groundwater base-level was described as "a drainage level for the aquifer that represents the lowest groundwater level that will occur from groundwater flow only" (Olin 1995). It is herein, in analogy, defined as the ultimate discharge zone down-gradient of groundwater basin. Groundwater base levels are basically grouped in two types: (a) the global marine base-level, and (b) the continental, terminal, internal drainage system, closed basin or termed as an endorheic base-level that attract and discharge convergent groundwater flow. An endorheic base level is usually described as a closed drainage basin that retains water and allows no outflow to other bodies of water. Precipitation that falls within the basin does not flow out and may only leave the drainage system by evaporation or seepage.

Groundwater basins and surface water basins that drain, approximately, the same region do not necessarily coincide. In some cases they can share roughly the same boundaries, divides and base-levels, whereas in other cases the same area can be drained by surface networks to a specific base-level and by groundwater systems to a different one. Endorheic surface water continental base-levels are relatively easily defined and delineated based on their adjoining surface drainage network system. Some endorheic groundwater base-levels, on the other hand, are not always easily delineated due to the scarcity of groundwater table data. Still, the interconnection between terminal surface water base-levels and lakes and adjoining groundwater systems were analyzed and established among others by Smith et al. (1997), Urbano et al. (2000, 2004), Holzbecher (2001), Gosselin and Khisty (2001), Winter (1999), Winter et al. (2002) and Pederson (2001). It is noticed that levels of many lakes that serve as surface water base-levels are also controlled by groundwater levels and the lakes serve also as groundwater base-levels (see also Sect. 5.2)

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An attempt is made herein to summarize, compile and compare results of studies, sometimes partial, regarding current groundwater base-levels as well as of paleo-ones, still within the hydrological "memory" time window, mostly from Neogene times to the present.

The book aims to propose a basic classification of groundwater base-levels, both marine and continental. The latter includes terminal and flow-through (intermediate) base-levels. Special attention is given to continental endorheic base-levels considerably below sea level whether connected hydrologically to the sea or not.

Base levels are subjected to changes in time and space. The factors that control base-level changes are also discussed in the book. Among these are: tectonic movements, isostatic changes as well as glacio-isostatic rebound of continents following deglaciation, eustatic sea level and lake level changes caused by climate changes, water table depressions caused by evapotranspiration, compaction, and capturing of groundwater basins. Some emphasis is also given to the impact of the claimed on-going global warming process, whether natural or anthropogenic (the green house effect) on base level changes. Changes are also caused by land subsidence due to man-made groundwater withdrawal or hydrocarbon exploitation.

The different methods and devices employed for measuring and monitoring current base-level changes are also described. Among these are marine gauges and mariographs to monitor sea and lake level changes, geodetic levelings by the GPS and INSAR methods to detect ground level changes, and monitoring devices to measure the response of the groundwater system. The different methods to reconstruct paleo and ancient base-level changes are also described. Among these are shallow and near shore marine and lake sediments, abrasional notches and platforms, paleo-karstic systems, location of archaeological sites, as well as the use of both radiogenic and stable isotopes and hydrological modeling.

Among other important topics that are discussed are Neogene to Holocene paleo- base- levels and their adjoining hydrological systems. In addition, the impact of base-level changes on capturing of groundwater basins and shift of divides are also discussed.

The configuration and changes of groundwater base-levels play a most important role in the response of the groundwater systems regarding salination and flushing processes. The discussed topics, concerning this matter, are: salination and flushing of coastal aquifers, salination of terminal continental base-levels, below sea level and connected hydraulically to the sea as well as density driven salination processes that occur in terminal continental base-levels, with no connection to the sea.

All the topics described above are accompanied and supported by selected examples and references from all over the world. Special emphasis is paid in this book to examples from the Mediterranean marine base-level and from the endorheic Dead Sea Rift base-level of Israel. This is due to the relatively high abundance and availability of data, as well as to the long term involvement of the authors in the study of these base-levels, that can serve as analogues to other base-levels where data do not exist or are scarce.

The present book does not pretend to list and describe all the existing and paleo base levels on earth. It attempts to describe the most known ones and particularly

those that render abundant available hydrogeological data. In some of the described cases, interpretation is made as to the nature of the described base levels, based primarily on the resemblance to other ones, despite their scarce available data.

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