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Hydrogeology
of a Large Oil-
and-Gas Basin in
Central Patagonia
San Jorge Gulf
Basin, Argentina

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To Nicolás, a little ray of sunshine

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Abstract

A comprehensive regional study of the groundwater hydrology of the San Jorge Gulf Basin (Argentina) is presented for the first time. It is an onshore area of 40,530 km² in an arid region, representative of the Extra-Andean Patagonia, between the Andes and the Atlantic Ocean.

The geohydrology and its basic components—hydrogeology, hydrodynamics, hydrochemistry, and environmental geohydrology—are analysed in a region with precipitations of barely 200 mm/year, a water deficit of 477 mm/year, and a limited occurrence of allochthonous watercourses. Groundwater is therefore essential, especially because it is the most important oil basin in the country, active since 1907, and with excellent prospects regarding the production of unconventional hydrocarbons (shale gas/oil, tight oil), still under development.

A lower or passive geohydrologic system and an upper or active one were recognized. The latter coincides with the most hydrocarbon-productive levels, in sites with ages that span from Early Cretaceous to Pleistocene.

Water in most of the aquifers ranges from brackish to saline, with the Tertiary ones being the only low-salinity units. In order to manage conflicts between uses—in particular between mining and domestic uses—a management and governance plan is proposed for the limited water resources, including low-quality groundwater, the underflow of the Senguerr River, which is the only relatively important watercourse, the reusable water of the injection for secondary recovery and the flow back of the exploitation of unconventional oil and gas (fracking). The use of freshwater aquifers is regulated by provincial protective legislation.

This book also discusses the indispensable groundwater resource protection policies, which are key for the region, and, above all, the need for hydrogeological studies, as at present they are limited or partial.

Keywords Geohydrology · Arid regions · Water deficit · Extra-Andean Patagonia · San Jorge Gulf Basin · Oil/gas exploitation · Unconventional hydrocarbons · Water management and governance

Chapter 1

Introduction

Abstract This first chapter, as well as outlining the purpose of this book, introduces the regional framework of the basin, i.e. the Argentinian Extra-Andean Patagonia—the territory in which the San Jorge Gulf Basin occurs—its geographical location, extension and physical borders. The main geomorphological units are described, together with aspects of the landscape formation and the hydrography. The latter is characterized by its, perennial nature, the nival or pluvio-nival regime of the main rivers, and the fact that they lose water to groundwater, a situation that also occurs in lakes and dams. The lithology of the surface geology is very diverse, with ages ranging from the Proterozoic to the Cenozoic: Tertiary clastic and pyroclastic deposits predominate, followed by Cretaceous sedimentary rocks and Jurassic–Cretaceous igneous rocks. The hydrogeology is mainly conditioned by the climate. There are post-Jurassic aquifers of interest that occur in porous media, as well as deep aquifers occurring in fissured media. Brackish to saline groundwater prevails, with the occurrence of fresh groundwater in the local arid climate being due to particular recharge mechanisms. Its use is restricted and mainly reserved for domestic supply. Hydrocarbon production and metal mining use large volumes, though it is water of lower quality. Such economic activities have displaced the original primary activity, which was sheep farming.

Keywords Purpose • Regional framework • Extra-Andean Patagonia • Regional geomorphology • Geology and hydrogeology • Groundwater quality • Water use • Water-using activities

It is the purpose of this book to characterize from a hydrogeological point of view one of the most special basins in Argentina: subjected to an arid climate, with a complex geology, scarcity of surface and groundwater resources, hosting important hydrocarbon (HC) deposits—both conventional (discovered in 1907) and unconventional—with groundwater historically fulfilling a fundamental role in its socio-economic development.

The San Jorge Gulf Basin is undoubtedly a very peculiar geographical and geological feature, located in an even more unique region: the Argentinian Extra-Andean Patagonia. Covering an area of 740,000 km², it is one of the most southern regions on the planet (35°–65° south latitude), with a climate in which the mean annual rainfall values fluctuate between 150 and 300 mm/yr. It is bordered to the north by the Colorado River, to the south by the Strait of Magellan, to the west by the Andes and to the east by the Atlantic Ocean (Fig. 1.1).

It is precisely the characteristics of the boundaries of the regional setting that highlight the above-mentioned singularity, since the western boundary—that is, the Andes—controls the regional climate as it intercepts the Westerlies, discharging up to 2500 mm/yr of rain on the windward side and creating a dry rain shadow to the east (Fig. 1.2).

The Andes, with their permanent snow and continental glaciers, feed the large rivers, nearly all perennial, which traverse the region in search of the ocean (Álvarez et al. 2006), such as the rivers Colorado, Limay-Neuquén-Negro, Chubut, Senguerr, Deseado, Santa Cruz, Coyle and Gallegos (Fig. 1.3).

The eastern boundary is the vast Atlantic Ocean, a discharge area for surface and groundwater runoff; the northern boundary coincides with the limit between the arid Patagonian region and the sub-humid centre; and the southern boundary is the Strait of Magellan, which connects the Atlantic and Pacific oceans.

The regional geomorphology shows a landscape with stepped tablelands descending towards the east from the Andean sector, interrupted by two cratonic massifs, the Somuncurá Massif to the north and the Deseado Massif to the south, and by an orographic belt called “Patagonides”, with a trend sub-parallel to the Andes (Coronato et al. 2008). The Patagonides develop from the centre of the region towards the north and they are composed of two sub-units: the Bernardides, in the area of the San Jorge Gulf Basin, and the Patagonian Andean foothills, in the northern sector (Ramos 1999). In Fig. 1.3, such large positive units are shown.

Every process of landscape formation has occurred in this area: *glacial*, mainly in the entire peri-Andean sector; *fluvio-glacial*, in vast extensions of the tablelands covered by gravels attributed to such an origin (Fidalgo and Riggi 1970); *marine*,

Fig. 1.1 Location of the San Jorge Gulf Basin in the Argentinian Extra-Andean Patagonia

