Journal of Hydrology: Regional Studies 2 (2014) 97–118

Contents lists available at ScienceDirect

Journal of Hydrology: Regional Studies

journal homepage: www.elsevier.com/locate/ejrh

End-member river water composition in the acidified Adirondack Region, Northern New York, USA

Jeffrey R. Chiarenzelli[a,*], Matthew C. Skeels[b]

[a] Department of Geology, St. Lawrence University, Canton, NY 13617, USA
[b] Department of Chemistry, St. Lawrence University, Canton, NY 13617, USA

ARTICLE INFO

Article history:
Received 15 February 2014
Received in revised form 20 August 2014
Accepted 30 August 2014
Available online 6 October 2014

Keywords:
Raquette River
Adirondacks mountains
Hurricane Irene
Baseflow
Stormflow

ABSTRACT

Study region: From its headwaters in the Adirondacks to its confluence with the St. Lawrence River, the Raquette flows across acidic crystalline rock, a marble dominated metasedimentary sequence, and Paleozoic sedimentary rocks with increasing capacity to neutralize acidity. Although its drainage basin is largely forested and has a limited population, seventeen hydroelectric reservoirs occur along its mid to lower reaches.

Study focus: The goal of the study was to document the geochemistry of Raquette River waters during discharge events. The river was sampled for 69 elements and 7 anions, along its length during stormflow associated with Tropical Storm Irene. One year later the same sites were sampled during a drought with a flow-duration percentage was 98.65.

New hydrological insights for the region: Samples collected during average discharge volumes documented chemical gradients corresponding to bedrock spatial distribution. These trends were muted during both stormflow and baseflow, and imply that other factors influence water chemistry during high and low-flow events. Our study documents an example of event river chemistry responding less to extremes of flow or variation in underlying geology than anticipated. During the stormflow sampling one sample had elevated specific conductance (160.4 $\mu S\,cm^{-1}$) and pH (8.21). This data, anomalous geochemistry, and images from Google Earth suggest that the river chemistry is sporadically impacted by discharge from a dolostone quarry located 6 km upstream during runoff events.

* Corresponding author at: 145 Brown Hall, Department of Geology, St. Lawrence University, Canton, NY 13617, USA. Tel.: +1 315 229 5202.
E-mail address: jchiaren@stlawu.edu (J.R. Chiarenzelli).

http://dx.doi.org/10.1016/j.ejrh.2014.08.003
2214-5818/

1. Introduction

1.1. Problem statement

Drever (1997) listed five major influences on the chemistry of natural waters including: climate, lithology, relief, rock/water interaction, and vegetation. Rock/water interaction, influenced by the proportions of runoff (overland flow) to baseflow is an important factor in the variation documented within individual hydrologic systems (Inamdar et al., 2013). Perturbations of natural hydrologic systems are common and numerous examples of anthropogenic factors, both intra- and extra-basinal, resulting in a strong impact on river water chemistry have been documented in the literature (e.g. Rothwell et al., 2007; Sanchez Espana et al., 2005).

Here we investigate water chemistry during both stormflow and baseflow at seventeen localities in the acidified (Jenkins et al., 2007), but largely undeveloped (Jenkins and Keal, 2004), Raquette River drainage basin within the Adirondack Region. Previous work (Chiarenzelli et al., 2012) has demonstrated that during near average discharge volumes water chemistry is distinct in stretches of the river underlain by three different bedrock terranes (Adirondack Highlands, Adirondack Lowlands, and St. Lawrence River Valley), which vary widely in their chemical composition and capacity to buffer acidity. Our primary goal is to characterize and compare the water composition down the length of the river during conditions of high and low discharge approximating end member compositions. Second, we discuss the factors that exert primary control on the variation in water chemistry within the drainage basin. Third, we present evidence for the unanticipated episodic impact of a dolostone quarry on river water chemistry in the lower reaches of the river.

1.2. The Raquette River

The Raquette River originates in the Central Adirondack Region near Raquette Lake, New York and has a drainage basin of 2900 km^2. It flows north approximately 280 km and drops more than 457 m in elevation to its confluence with the St. Lawrence River near Massena (Fig. 1). During most of its length it flows within the Adirondack Park, a sparsely populated region of private and public lands with limited and highly regulated development, extensive forest cover, and limited agricultural use (Jenkins and Keal, 2004). A system of dams, some built more than a century ago, were used to raise water levels in pre-existing lakes (e.g. Raquette, Forked, Long, and Tupper lakes) and to facilitate spring logging runs. Large reservoirs (e.g. Carry Falls, Blake, Rainbow Falls, Five Falls, and Higley Flow), below the USGS gauging station at Piercefield, were built in the 1950s to provide water storage capacity for hydropower in the river's mid to lower reaches, where seventeen hydropower dams with a generating capacity of 181 MW occur (Supplemental Table 1). In addition to its importance as hydropower resource, the Raquette River serves as a water source for several communities along its banks, as a recreational resource, and as an important cultural resource for the Native American community at Akwesasne.

Supplementary material related to this article can be found, in the online version, at doi:10.1016/j.ejrh.2014.08.003.

1.3. Geology of the Raquette River drainage basin

Along the course of its length the river traverses three very distinct geological terranes including the Adirondack Highlands, Adirondack Lowlands, and St. Lawrence River Valley (Chiarenzelli et al., 2012). The approximate center of the Adirondack topographic dome, the High Peaks Region, is east of the Raquette River drainage basin and underlain by the large Marcy Anorthosite massif. The anorthosite is surrounded by a complex assemblage of highly metamorphosed Precambrian crystalline bedrock lithologies ranging in age from about 1.00 to 1.35 billion years old that make up what is referred to as the Adirondack Highlands (Regan et al., 2011). In addition to its domal topographic expression, this area is characterized by highly deformed and metamorphosed igneous rocks, many of which were intruded along with the anorthosite deep into the roots of an ancient mountain belt. This mountain belt was part of a global system of continental collisions (i.e. orogenic events) that resulted in the formation of the supercontinent of Rodinia by 1.0 billion years ago. The Adirondacks are part of a