



Geologic CO₂ input into groundwater and the atmosphere, Soda Springs, ID, USA



J.L. Lewicki ^{a,*}, G.E. Hilley ^b, L. Dobeck ^c, T.L. McLing ^d, B.M. Kennedy ^f, M. Bill ^f, B.D.V. Marino ^e

^a U.S. Geological Survey, Menlo Park, CA 94025, USA

^b Department of Geological and Environmental Sciences, Stanford University, Stanford, CA 94305, USA

^c Department of Chemistry and Biochemistry, Montana State University, Bozeman, MT 59717, USA

^d Idaho National Laboratory, Idaho Falls, ID 83415, USA

^e Planetary Emissions Management, Inc., Cambridge, MA 02142, USA

^f Earth Sciences Division, Lawrence Berkeley National Laboratory, Berkeley, CA 94720, USA

ARTICLE INFO

Article history:

Accepted 20 June 2012

Available online 30 June 2012

Keywords:

Springs

CO₂ degassing

Eddy covariance

Mantle

Metamorphic decarbonation

Accumulation chamber

ABSTRACT

A set of CO₂ flux, geochemical, and hydrologic measurement techniques was used to characterize the source of and quantify gaseous and dissolved CO₂ discharges from the area of Soda Springs, southeastern Idaho. An eddy covariance system was deployed for ~one month near a bubbling spring and measured net CO₂ fluxes from -74 to $1147 \text{ g m}^{-2} \text{ d}^{-1}$. An inversion of measured eddy covariance CO₂ fluxes and corresponding modeled source weight functions mapped the surface CO₂ flux distribution within and quantified CO₂ emission rate (24.9 t d^{-1}) from a 0.05 km^2 area surrounding the spring. Soil CO₂ fluxes (<1 to $52,178 \text{ g m}^{-2} \text{ d}^{-1}$) were measured within a 0.05 km^2 area of diffuse degassing using the accumulation chamber method. The estimated CO₂ emission rate from this area was 49 t d^{-1} . A carbon mass balance approach was used to estimate dissolved CO₂ discharges from contributing sources at nine springs and the Soda Springs geysers. Total dissolved inorganic carbon (as CO₂) discharge for all sampled groundwater features was 57.1 t d^{-1} . Of this quantity, approximately 3% was derived from biogenic carbon dissolved in infiltrating groundwater, 35% was derived from carbonate mineral dissolution within the aquifer(s), and 62% was derived from deep source(s). Isotopic compositions of helium ($1.74\text{--}2.37 R_a$) and deeply derived carbon ($\delta^{13}\text{C} \approx 3\text{‰}$) suggested contribution of volatiles from mantle and carbonate sources. Assuming that the deeply derived CO₂ discharge estimated for sampled groundwater features ($\sim 35 \text{ t d}^{-1}$) is representative of springs throughout the study area, the total rate of deeply derived CO₂ input into the groundwater system within this area could be $\sim 350 \text{ t d}^{-1}$, similar to CO₂ emission rates from a number of quiescent volcanoes.

Published by Elsevier B.V.

1. Introduction

Quantification of CO₂ emissions from volcanic, geothermal, and metamorphic (VGM) systems over a range of temporal and spatial scales is required to monitor volcanic activity, processes associated with geothermal energy production, and health and environmental hazards associated with elevated CO₂ concentrations, as well as to explore for geothermal energy potential. In addition, although present-day emissions of CO₂ derived from non-volcanic (not from the craters and flanks of volcanoes) sources such as metamorphism and subsurface magmatism are likely globally significant (e.g., Kerrick et al., 1995; Kerrick, 2001), a relatively limited number of estimates of this degassing are available (e.g., Kerrick et al., 1995; Seward and Kerrick, 1996; Chiodini et al., 1999, 2000; Rogie et al., 2000; Becker et al., 2008; Evans et al., 2008; Frondini et al., 2008). Further studies are required to quantify the contribution of CO₂ degassing from non-volcanic sources to the global carbon cycle.

A number of methods have been applied to characterize the discharge of CO₂ from soil, groundwater, and surface water sources in

VGM systems. For example, the accumulation chamber technique (e.g., Chiodini et al., 1998) has been a reliable technique to measure the spatial distribution of soil CO₂ fluxes and estimate total CO₂ emission rates in VGM regions. Limitations of the accumulation chamber method, however, include the measurement's small spatial scale ($<1 \text{ m}^2$) and inability to continuously measure variations in CO₂ fluxes at a large number of point locations across a study area. Spring flow rate measurements have been coupled with aqueous chemical and isotopic data to estimate dissolved discharges of geologic CO₂ (e.g., Chiodini et al., 1999, 2000; Evans et al., 2002, 2006; Frondini et al., 2008), whereas direct measurements of gaseous CO₂ emissions from bubbling springs and pools have been carried out by trapping the gas in an inverted container and measuring the CO₂ concentration of the gas and the gas outflow rate from the container (e.g., Rogie et al., 2000; Werner et al., 2000a). Eddy covariance (EC) is a micrometeorological technique (e.g., Baldocchi, 2003) proposed as a method to measure CO₂ emissions from VGM systems (Werner et al., 2000b; Anderson and Farrar, 2001; Werner et al., 2003; Lewicki et al., 2008, 2012). EC has the advantage of providing an automated and time and space-averaged flux measurement, with a spatial scale significantly larger ($\text{m}^2\text{--km}^2$) than that of aforementioned alternative

* Corresponding author. Fax: +1 650 329 4538.

E-mail address: jlewicki@usgs.gov (J.L. Lewicki).

approaches. Lewicki et al. (2012) showed that EC could be used to map the spatial distribution of and quantify volcanic CO₂ emissions from the soil. However, this ability has yet to be tested where geologic CO₂ is emitted from ground and surface water sources.

Numerous carbonated springs and extensive travertine deposits are distributed throughout southeastern Idaho. The geochemistry of a number of these springs has been studied as part of regional hydrologic and geothermal investigations (e.g., Young and Mitchell, 1973; Mitchell, 1976; Muller and Mayo, 1983; Hutsinpillar and Parry, 1985; Mayo et al., 1985; Semenza, 2011). While metamorphic decarbonation of marine carbonates was suggested to be a significant source of the CO₂ in springs (Mayo et al., 1985), no attempt has yet been made to quantify rates of CO₂ degassing.

We investigate non-volcanic CO₂ degassing near the town of Soda Springs, Idaho. Here we apply a set of CO₂ flux, geochemical, and

hydrologic measurement techniques to quantify gaseous and dissolved CO₂ discharges. Specifically, we test for the first time the ability of EC to quantify gaseous CO₂ emissions from a spring source. Soil CO₂ emissions from an area of diffuse degassing are measured using the accumulation chamber method. Furthermore, dissolved CO₂ discharges from contributing sources are estimated at selected springs using a carbon mass balance approach (Chiodini et al., 1999, 2000). Finally, we make a preliminary estimate of total dissolved CO₂ discharge derived from deep geologic source(s) for the entire study area.

2. Geologic and hydrogeologic background

The study area is located in southeastern Idaho, within the Sevier fold-and-thrust belt and the northeasternmost Basin and Range province (Fig. 1a). The area is also located adjacent to the southern border of the eastern Snake River Plain volcanic province. Structures

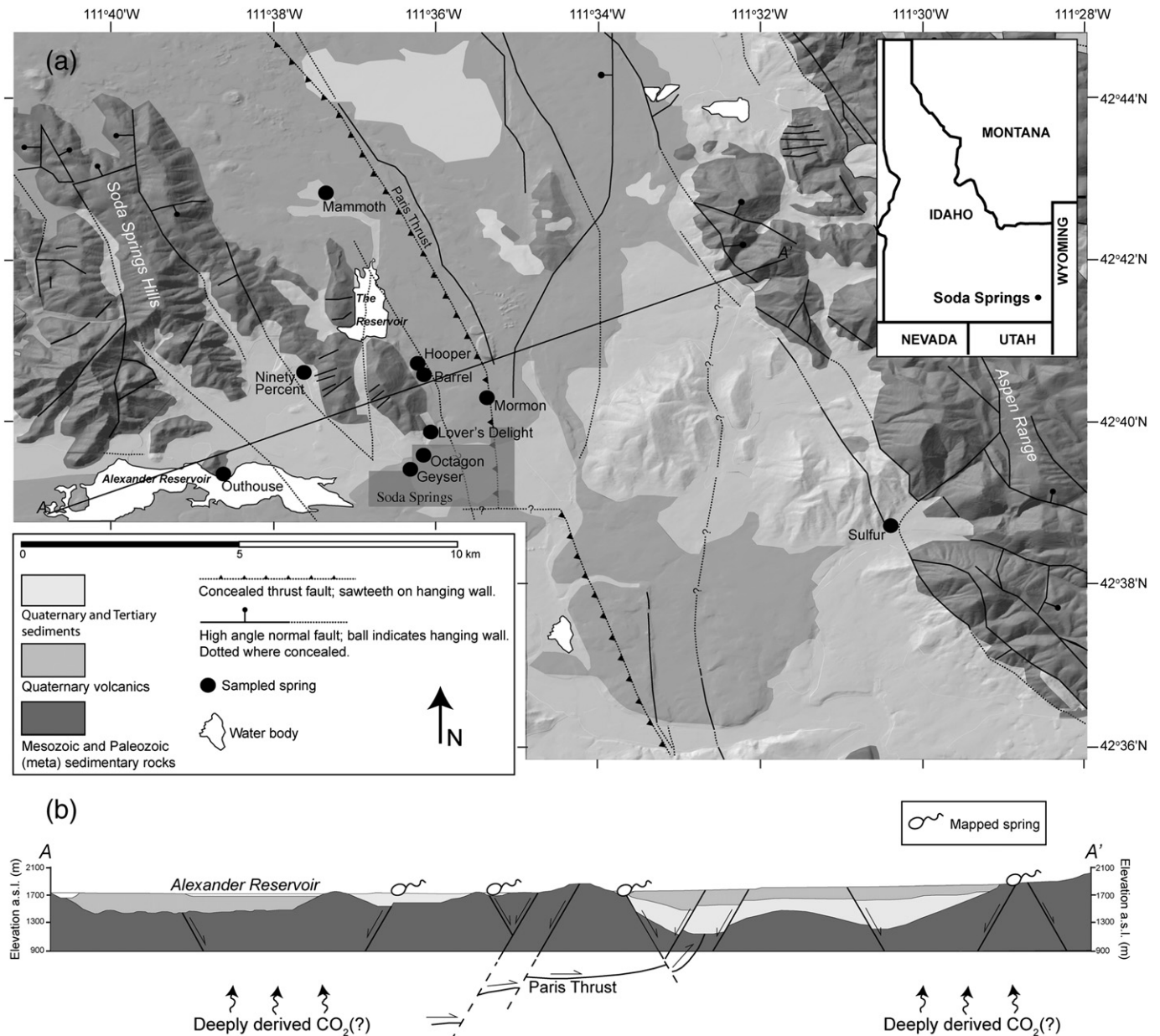


Fig. 1. (a) Map of Soda Springs study area with groundwater sampling locations (modified from Armstrong, 1969; Mabey and Oriel, 1970; Semenza, 2011). Town of Soda Springs and cross-section A–A' are also shown. (b) Geologic cross section A–A' with springs mapped by Semenza (2011). Spring waters are derived from Paleozoic carbonate aquifers and have been estimated to circulate to depths of about 1000 to 2000 m (Mansfield, 1927; Mayo et al., 1985). Source locations and migration pathways of deeply derived CO₂ are unknown.

Download English Version:

<https://daneshyari.com/en/article/4699126>

Download Persian Version:

<https://daneshyari.com/article/4699126>

[Daneshyari.com](https://daneshyari.com)