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Preface

Introduction to the special issue on 'Frontiers in Gas Geochemistry'

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ABSTRACT

The study of the geochemistry of gases pervades the Earth and Environmental Sciences. This is due in no small measure to the well-established thermodynamic properties of gases which allow their application to a variety of processes occurring over a wide spectrum of natural conditions. In this respect, both major and associated minor gases have been proven useful: indeed, the trace gases have been particularly important given their role as sensitive geochemical tracers. Examples where gas geochemistry places key constraints on geochemical processes include the degassing history of the solid Earth to form the atmosphere and oceans, the origin and migration characteristics of hydrocarbon deposits, the scale of climate variability, the P–T characteristics of geothermal reservoirs, and the dynamics of the earthquake cycle and volcanic activity, to name but a few. This volume continues this rich tradition with an eclectic selection of papers aimed at exploring and exploiting gas geochemistry over a myriad set of research themes.

1. Introduction

The continuing utility of gas geochemistry is predicated upon innovative approaches involved in the detection, collection, extraction, preparation and measurement of a variety of gas species and their isotopes as well as the development of new modeling techniques to further aid in interpretation and understanding. This special volume documents recent activities and advances in gas geochemistry, illustrating the diverse geochemical characterization of gases and their application to a number of contemporary research themes. The 11th incarnation of the International Conference on Gas Geochemistry (ICGG), held in La Jolla, California in November, 2011, represented the biennial gathering of gas geochemists from across the geosciences spectrum (and the globe), where the common objective is to understand, exploit and probe the usefulness and limitations of gases in a variety of applications. This special issue of Chemical Geology 'Frontiers in Gas Geochemistry' reflects this diversity in scope and application of gas geochemistry.

2. Themes

The 27 papers of this volume can be broadly grouped into eight general themes noting that there is considerable overlap for some contributions. First, hydrothermal fluids and reservoirs have proven a popular target for gas geochemists and this volume contains its fair share of contributions aimed at understanding the origin, nature and extent of geothermal resources, their relationship to geodynamic setting, as well as associated subsurface processes such as fluid mixing and residence times, as well as degassing mechanisms — all of which accompany heat transfer to the surface. Magro et al. (2013–this issue) use gas data from geothermal wells to characterize subsurface conditions of the Palinpinon geothermal field in the Philippines. Darrah et al. (2013–this issue) show that volatiles from the Dallol hydrothermal area in the Afar region have a mantle plume influence whereas De Moor et al. (2013–this issue) report on gases from hot springs and cold CO_2 vents in the Rungwe volcanic province, East African Rift. Yokochi et al. (2013–this issue) report and model radiogenic noble gas contents (^{39}Ar, ^{81}Kr and ^{85}Kr) at Yellowstone National Park (USA) to show that hydrothermal fluid residence times range from 30 to ~100 kyr in different basins of the park.

The second category focuses on gas fluxes, particularly CO_2, with respect to both mantle and crustal contributions to the total output inventory. Inguaggiato et al. (2013–this issue) quantify CO_2 output from Stromboli Island (Italy) through a detailed survey of both crater and soil gas degassing. Lewicki et al. (2013–this issue) report on Soda Springs, Idaho (USA), and show that the CO_2 flux at this locality is comparable to that of a quiescently-degassing volcano. Kämpf et al. (2013–this issue) provide a detailed temporal and spatial study of mofettes and soil gases of the western Eger Rift (Czech Republic). The study by Tang et al. (2013–this issue) also considers CO_2 fluxes (as well as other gaseous species) but on a different scale altogether — their study targets the Permo-Triassic boundary and estimates the magnitude of gas release associated with the most severe mass extinction in the geological record.

A third and related theme involves gas loss through faulted/rifted segments of Earth's crust. On a regional scale, Kulongoski et al.

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(2013–this issue) quantify CO_2 and He loss from the Big Bend section of the San Andreas Fault in California. Italiano et al. (2013–this issue) characterize CO_2, CH_4 and He discharges at the intersection of the North and East Anatolian faults (Turkey). In contrast to these major plate boundary faults, more localized (natural gas) degassing is reported by Etiope et al. (2013–this issue) who quantify explosive levels of CH_4 and toxic levels of H_2S issuing from thermogenic seepage zones along the Ionian coastline (western Greece). Polyak et al. (2013–this issue) use noble gas and stable isotopes to provide evidence of magma-related degassing associated with reactivation of rifting though Precambrian basement of the remote Chukotla Peninsula (Russia). Barry et al. (2013–this issue) report He and CO_2 isotope and relative abundance characteristics of hydrothermal fluids and CO_2 vents at Rungwe Volcanic Province at the southern end of the East African Rift, and explore the discrepancy observed in $^3He/^4He$ ratios between fluids and spatially-related lavas.

Fourth, the topic of gas chemistry and its response, or lack thereof, to seismic perturbation is tackled by a number of authors. Tramutoli et al. (2013–this issue) studied the sensitivity of Thermal Infrared radiation to gas emissions, particularly CO_2 and CH_4, and reported anomalous patterns over the Azerbaijan region during a mud volcano eruption in 1995. Co-seismic changes in CO_2 emissions were reported by Dadomo et al. (2013–this issue) during the April, 2009 L'Aquila (Italy) earthquake whereas Woith et al. (2013–this issue) used radon gas together with fluid chemistry to argue for a transient geochemical signal associated with the 1998 Adana (Turkey) earthquake. Zheng et al. (2013–this issue) concluded that transient gas emissions from the Qingzhu River (China), following the 2008 Wenchuan earthquake, were caused by fault/fracture openings induced by the earthquake activity.

Hydrocarbon gases fall into the fifth category. Tilley and Muehlenbachs (2013–this issue) review the application of gas chemistry to shale gas exploration strategies, particularly the isotope systematics of C1–C3 gases as a proxy for gas maturity. This topic is taken up by Xia et al. (2013–this issue) who argue that indigenous mixing mechanisms are the primary control on observed isotopic reversals. Kawagucci et al. (2013–this issue) explore the origin of hydrothermal methane in the Okinawa Trough, and consider the significance of the C1 isotope characteristics and C1/C2 abundance characteristics as indicators of methane origins. Generation of coalbed methane by microbes is the topic of the contribution by Furmann et al. (2013–this issue) whose study considers diagnostic indicators of enhanced biodegradation in different coals from the Illinois Basin, Indiana (USA). Finally, Hunt et al. (2013–this issue) explore the use of noble gas fractionation patterns as a means to distinguish methane derived from dissociating gas hydrates versus methane emitted from shallow sediments, coalbeds, and/or other crustal reservoirs.

The volatile systematics of the subduction process is the sixth theme in this volume. Taran et al. (2013–this issue) report the chemical and isotope composition of bubbling and dissolved gases in thermal springs along the Mexican Pacific coast, and argue that spatial patterns are consistent with the presence of a 'slab window' between the subducting Cocos and Rivera plates. Volcanoes of the western Sunda arc — the islands of Sumatra–Java–Bali — are the targets of the study by Halldórsson et al. (2013–this issue) who resolve the volcanic gas output into mantle (including subducted slab) and (upper) crustal contributions, showing that the principal contributor of volcanic gases is sediments subducted into the mantle on the down-going Indo-Australian Plate.

The final two categories include groundwater-related gases and gases associated with ore-fluid evolution. Freundt et al. (2013–this issue) document the evolution of soil air composition and its effect on noble gas concentrations. They report that noble gas concentrations vary inversely with $(CO_2 + O_2)$ contents, showing that this effect could potentially lead to discrepancies in paleo-temperature estimates based on the solubility characteristics of noble gases in groundwater. A related study explores the behavior of the closed-system equilibration model which also exploits noble gas concentrations in groundwater as a proxy for paleo-temperatures (Jung et al., 2013–this issue). The special issue is rounded off with a noble gas isotope study of the world's largest magmatic sulfide deposit at Jinchuan, China. Zhang et al. (2013–this issue) report He–Ne–Ar isotope characterization of sulfide and silicate mineral separates, and argue that crustal and atmospheric fluids were added to the parental magma of the Jinchuan intrusion during ore-genesis.

3. Concluding remarks

The ICGG series of meetings represent a lively forum for new ideas and discussions focused exclusively on gas geochemistry. The meetings are complemented by a field trip where delegates can observe present-day degassing features. Proceedings of the meetings are normally published as Special Issues of peer-reviewed journals, as in the present case. ICGG continues to attract widespread participation — in the form of oral and poster presentations — from a diverse international audience. We endorse the approach and philosophy of the ICGG format, and encourage attendance at the next meeting scheduled to be held in Greece in September, 2013.

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