Groundwater depletion: A U.S. national assessment and global perspective

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Development of groundwater resources for agricultural, industrial, and municipal purposes greatly expanded during the 20th century, and economic gains from groundwater use have been dramatic. In many places, however, groundwater reserves have been depleted to the extent that well yields have decreased, pumping costs have increased, water quality has deteriorated, aquatic ecosystems have been damaged by reduced groundwater discharge, and land has subsided irreversibly. Some causes and effects of groundwater depletion are neither obvious nor easy to assess. If cumulative long-term global depletion is large, it will represent a substantial net transfer of mass from land to the oceans, thereby contributing to sea-level rise. Much groundwater pumped from confined aquifers is derived from storage losses in adjacent confining layers. Nevertheless, depletion in low-permeability layers is difficult to estimate, rarely monitored, and too often overlooked. A new simplified method for estimating depletion from confining layers was developed, tested, and applied. Results indicate that depletion in confining layers can greatly exceed the depletion from the confined aquifer itself. (For example, in the confined Dakota Aquifer, about 98 percent of the water removed from storage was derived from depletion in adjacent confining units.) A U.S. national groundwater depletion census indicates that about 800 km^3 of water was depleted from groundwater systems in the U.S. during the 20^{th} century—equivalent to a sea-level rise of approximately 2.2 mm. Long-term global groundwater depletion since 1900 totalled about 3,400 km^3 through 2000 and 4,500 km^3 through 2008, equivalent to a sea-level rise of approximately 9.3 and 12.6 mm, respectively. The rate of annual depletion has increased markedly since about 1950, with maximum rates occurring during the most recent period (2000-2008), when it averaged about 145 km^3/yr (equivalent to 0.23 mm/yr of sea-level rise). This recent average rate would explain about 13 percent of the reported long-term rate of sea-level rise of 1.8 mm/yr. Worldwide, the magnitude of groundwater depletion is a small but nontrivial contribution to sea-level rise during the 20^{th} century.

Discovery of new hydrothermal active fields in the South-West Pacific. Organic geochemistry of the fluids

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Back-arc basins in the South-West Pacific have been investigated for hydrothermal activity in the last 20 years. Several hydrothermal fields have been discovered in the Lau basin, Manus basin and North Fiji basin. A new area off-shore the Futuna island was surveyed in fall 2010 during a French cruise conducted by Ifremer and two new hydrothermal active fields (Amanaki and Kulo Lasi) were discovered. The plumes were first evidenced by the use of physical and geochemical tracers. At Kulo Lasi, nephelometry, Mn, CH_4 He profiles strongly correlated and consistently showed a maximal anomaly in the water column at about 1200 m depth. Concentrations of CH_4 up to 1200 $nL.L^{-1}$ and up to 30 nM for Mn were detected. High-resolution bathymetry supported the tracers indications, showing a caldeira in the vicinity culminating at 1200 m. Numerous small black smokers were then discovered on the seafloor during our first submersible dive. CTD profiles were recorded around and on the field during 9 CTD operations and 6 Nautile dives. Alongside, water column samples and hydrothermal fluids samples were collected. On the one hand, physics and geochemistry of the Kulo Lasi plume will be discussed here. On the other hand, relatively elevated concentrations of H_2 and CO_2 have been measured in the fluids from Kulo Lasi (gas and inorganic geochemistry of the fluids will be the focus of another presentation by J.L. Charlou). In the presence of H_2 and CO_2, catalytic abiogenic reactions (e.g. Sabatier, Fischer Tropsch) may occur and generate hydrocarbons [1, 2]. Supercritical seawater (Pc = 298 bar, Tc = 407 °C) is a favourable media for cleavages, condensations, cyclisations, hydrolysis, oxydation, hydrogenation and hydroformylation. A great variety of organic compounds (heavier hydrocarbons, prebiotic molecules [3, 4]) may thus be produced at the Kulo Lasi hydrothermal field. The preliminary results on the organic geochemistry of the hot fluids will be presented here.

[1] Proskurowski *et al*. (2008) *Science,* **319**, 604–607. [2] Sherwood Lollar *et al.* (2006) *Chem. Geol.* **226**, 328–339. [3] Konn *et al*. (2009) *Chem. Geol*. **258**, 299–314. [4] Konn *et al.* (2011) *Geobiology,* **9**, 79–93.