Are arctic ecosystems exceptionally vulnerable to global emissions of mercury?

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Almost one decade ago atmospheric mercury depletion events (AMDEs) were reported to occur in the High Arctic after polar sunrise (Schroeder et al., 1998), and these depletion events were shown to result in mercury deposition to the surface (Steffen et al., 2008). Although deposited mercury is bioavailable (Lindberg et al., 2002) it remains unclear how much – or even whether – the mercury actually enters foodwebs (Hammerschmidt and Fitzgerald, 2008). These findings raise the question of whether or not the Arctic is an enhanced sink for global mercury emissions, and whether the deposited mercury might explain high mercury concentrations observed in some high trophic level Arctic biota. A recently constructed mercury mass balance for the Arctic Ocean (Outridge et al., 2008) found that atmospheric deposition is important, accounting for perhaps half of the mercury inputs, but that there are also other important sources (ocean currents, rivers) and there is a large reservoir of mercury in the ocean that could be worked on by various biogeochemical processes (e.g., Poulain et al., 2007; Cossa et al., 2009). Perhaps more intriguing is the lack of any correspondence between trends for mercury in Arctic air (Steffen et al., 2008), and mercury trends observed in high-trophic level aquatic animals (Lockhart et al., 2005). This leaves open the questions of whether or not the Arctic is a special sink, what proportion of deposited mercury ends up in food webs (Loseto et al., 2008), what factors produce variability in mercury concentration in biota, and how might recent climate change, especially the melting of ice, alter the Arctic's mercury cycle (e.g., Macdonald et al., 2005)? These questions need answers before we can properly assess the risks mercury presents to the ecosystem.

In this presentation we focus particularly on the Arctic Ocean and approach these questions by first examining what is known about the quantities and pathways of mercury cycling into and out of the Arctic. We then examine abiotic and biotic processes that transform mercury to more toxic or bioavailable forms to be taken up in foodwebs, and present available trend data for mercury in different reservoirs. Finally, we propose how climate change in the cryosphere might alter mercury exposure by releasing archived mercury or transforming cycling mercury. Throughout the discussion we point out weaknesses in our understanding of the mercury cycle that presently limit the development of a realistic model for the mercury cycle in the Arctic.

The Brazeau Nisku Q-pool: From sour gas reservoir to acid gas storage

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The Brazeau Nisku Q-Pool in west-central Alberta, Canada, was discovered in the 1980s as a sour gas reservoir in the Upper Devonian Nisku Formation. The host rocks consist almost exclusively of dolomite, with minor amounts of anhydrite. The Brazeau Q-Pool is part of a reef trend that contains oil, sweet and sour gas condensate at depths ranging from about 2300 m in the northeast to more than 4200 m in the southwest, with a thickness of about 80 to 100 m. A unique feature of this play is that the hydrocarbons are contained in numerous closely spaced pools that have been essentially isolated hydrodynamically from one another since hydrocarbon migration and entrapment about 50 - 60 million years ago, as shown by initial reservoir pressures and gas compositions. The hydrodynamic isolation renders these pools suitable for acid gas (H_2S + CO_2) injection and/or carbon dioxide (CO_2) sequestration.

Today the Brazeau Nisku Q-Pool is one of more than forty acid gas injection operations currently active in western Canada. A thorough stratigraphic, diagenetic, mineralogical, and hydrogeological evaluation of the Nisku Formation suggests that the injected acid gas will remain in the structure that contains the Q-Pool on a geological time scale. In the unlikely case of migration out of the Q-Pool, the acid gas plume would disperse and dissolve in deep formation waters along the flow path. The only possibility for upward leakage of acid gas rapid enough to be of human concern is through wells that were improperly completed and/or are abandoned and are not monitored.