Natural and anthropogenic iodine in Atacama: sources, sinks and cycling of iodine in a hyperarid continental margin

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The Atacama region in northern Chile hosts the driest desert on Earth and is the world's premier iodine production province, only seconded by the Chiba brine fields in Japan. The origin of iodine enrichment in Atacama is controversial and fundamentally different processes have been invoked over the years, that involve marine, aeolian and more recently deep sedimentary and groundwater sources.

We present the first comprehensive survey of iodine concentrations and isotopic ratios (^{129}I/I) of different geochemical reservoirs in Atacama, including nitrate deposits, supergene copper ores, marine sedimentary rocks, geothermal fluids, groundwater and meteoric water. Nitrate deposits were found to have iodine concentrations significantly higher than mean values in the earth crust (~700 ppm). These high values are followed by soil samples above supergene copper deposits and Mesozoic sedimentary rocks. In case of fluids, the highest concentrations were measured in groundwater below nitrates in the Central Depression (3.5-10 ppm) and in geothermal fluids in the volcanic arc (1-3 ppm).

In most solid reservoirs, ^{129}I/I values are below the pre-anthropogenic input ratio of 1500 x 10^{-15}, demonstrating that anthropogenic additions are absent in them. Regarding fluids, seawater presents the highest ^{129}I/I ratios (~11000 x 10^{-15}), followed bygroundwater below nitrates is ~10000 x 10^{-15}, while ^{129}I/I ratios in fluids from Western Cordillera are between 2000 and 5000 x 10^{-15}. The large variation observed in ^{129}I/I ratios is explained by a mixing of fluids from different sources. Our results indicate an extensive fluid circulation in the Chilean margin for at least 25 m.a., where deep water and shallower groundwater flow play an essential role in the iodine transport and accumulation. We suggest that the regional-scale iodine enrichment in Atacama is the result of a unique combination of geological, hydrological and tectonic conditions, and is strongly tied to large-scale groundwater flow over millions-of-years scales.