ORIGIN OF SULFATE IN THE SALAR DE ATACAMA AND THE CORDILLERA DE LA SAL, INITIAL RESULTS OF AN ISOTOPIC STUDY

Baruch SPIRO(1) and Guillermo CHONG(2)

(1) NERC Isotope Geosciences Laboratory, Keyworth, Nottingham, NG12 5GG U.K.

(2) Departamento de Geosciencias, Universidad Catolica del Norte, Antofagasta, Chile.

KEY WORDS: Salar, evaporites, isotopes, sulfur, strontium

INTRODUCTION

Salars occur in inland basins in the arid zones throughout South America from near-shore areas to the Altiplano. The origin of salts in the salars can be attributed to oceanic input as described for example for SW Australia (Chivas et al. 1991), or to a volcanic source. While the distribution of evaporites can be modified by subsequent dissolution-precipitation episodes, triggered by exposure of evaporitic deposits to weathering due to uplift. The Salar de Atacama in Northern Chile located about 200 Km from the Pacific coast at an altitude of 2300m with ridges of up to 3000m elevation in between, provides an excellent setting to adress the problem. Moreover the adjacent Cordillera de la Sal located to the west of the Salar contains a thick section of evaporites in the San Pedro Formation deposited in the Oligocene and deformed during the Miocene (Naranjo et al. 1994), provides a comparison to test wehether or not the same sources and processes were active at that time.

The present reconnaissance study uses the isotopic composition of sulfur and strontium as tracers for the origin of sulfate in the waters feeding the Salar de Atacama, the currently forming evaporitic deposits, and those exposed in the Cordillera de la Sal.

RESULTS

Water samples were collected from springs and wells to the north and east of the Salar de Atacama and within the salar itself, locally with the associated evaporites. The variation in chemistry of the water (not further discussed here) bears evidence to the complexity of the hydrological system. Several evaporite samples were collected along a transect across the San Pedro Formation in the Cordillera de la Sal.

The isotopic composition of the water ($\delta^{18}O$ and δD) was determined in order to characterise the fluids associated with the transportation of the solutes of interest. The copositions range between -8.7, -64.1 and +5.9 and -1.7‰ for $\delta^{18}O$ and δD respectively. The lower values fall on the Global Meteoric Water Line and the variations between samples are probably due mainly to differences between recharge areas. The higher values form an array which indicates evaporation under low humidity conditions.

The sulfur isotope results (δ^{34}SCDT) of the dissolved sulfate are in the range 3.4 to 7.0‰ and show no relation to the concentrations of dissolved sulfate or chloride. These values are lower than those of sea water sulfate throughout the Phanerozoic (e.g. Claypool et al. 1980). The initial $\delta^{34}S$ of the dissolved sulfate seems to be determined by that of the SO2 emitted by volcanoes and subsequently modified by leaching of the volcanic rocks. The two values recorded from evaporites within the Salar (4.3 and 5.4‰) are within this range. The $\delta^{34}S$ of the Cordillera de la Sal sulfates have a range 3.0 to 5.4‰ i.e. in the lower part of the range of the present day dissolved sulphate.

Strontium isotope ratios ($^{87}Sr/^{86}Sr$) recorded from the water samples are in the range 0.70755 to 0.70980, which in general correspond with values recorded from the volcanic rocks in the adjacent volcanoes. The values recorded from the Cordillera de la Sal (0.70681 to 0.70799) are in part lower than those of dissolved sulfate and corresponds to the values measured in the nearby Codillera Domeyko (Pankhurst, unpublished). The lowest ratios are recorded in the water of the San Pedro de Atacama spring where the spring waters are flowing next to the exposed evaporites of the Cordillera de la Sal and at Reine near the southern end of the salar ($^{87}S/^{86}Sr$ of 0.70760) where the spring waters pass Cretaceous limestones with $^{87}Sr/^{86}Sr$ of 0.70775. All the values recorded are lower than the 0.70910 ratio of present day ocean water. These ratios seem to relate to the ratios of the bedrocks with which the solutions come in contact

CONCLUSIONS

The waters draining into the Salar de Atacama have isotopic compositions ($\delta^{34}S$ and $^{87}Sr/^{86}Sr$) indicative of igneous origin of the respective solutes.

The evaporites of the San Pedro Formation in the Cordillera de la Sal have similar $\delta^{34}S$ and lower $^{87}Sr/^{86}Sr$ ratios, in line with change in bedrock which is or was in contact with the fluids.

The isotopic composition of species dissolved in waters currently draining into the Salar de Atacama, in evaporitic minerals precipitating from these waters or of evaporitic minerals deposited during the Oligocene, do not support the hypothesis that seawater is the main source of solutes for the Salar de Atacama nor did it contribute significantly to the Oligocene evaporites of the Cordillera de la Sal.

These results and conclusions have implications on the assessment of sources of salinity in arid zones.

REFERNCES

Chivas A.R. Andrew, A.S. Lyons W.B. Bird M.I. and Donnelly T.H. 1991. Isotopic constraints on the origin of salts in Australian Playas, 1. Sulphur. Paleogeogr. Paleoclimatol., Paleoecol., 84 309-332.

Claypool G.E. Holser W.T., Kaplan I.R. Sakai H. and Zak I. 1980. The age curves of sulfur and oxygen isotopes in marine sulfate and their mutual interpretation. Chem. Geol. 28 199-260.

Naranjo J.A. Remirez C.F. and Peskoff R.1994. Morphostratigraphic evolution of the northwestern margin of the Salar de Atacama basin (23^{o}S-68^{o}W). Revista Geologica de Chile 21 91-103.