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# The Presence and Distribution of Salts as a Palaeoprecipitation Proxy in Atacama Soils

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The Atacama Desert in northern Chile (17 to 27° S) is the driest and oldest warm desert on Earth and contains unique abundances of atmospherically-derived salts such as nitrate and perchlorate (Ewing et al., 2006; Jackson et al., 2015). Near-surface accumulation of extremely soluble salts indicates a scarcity of long-term precipitation-driven leaching from Atacama soils. The prolonged absence of substantial precipitation has enabled nitrate and perchlorate to accumulate for millions of years to measurable levels, while interacting with occasional rainfall to move vertically through the soil profile. We investigate the near-surface presence and distribution of atmospherically-generated soluble salts at Earth's most arid extreme, aiming to quantify Atacama palaeoprecipitation during the Quaternary. Previous field and modelling studies have revealed a strong correlation between the depth of peak nitrate and past precipitation events in the U.S. desert southwest (Walvoord et al., 2003; Marion et al., 2008). We extend these studies to regions of much lower rainfall, and report the largest ever near-surface concentrations of nitrate and perchlorate in Earth's soils.

We present salt distribution profiles from soil pits in six localities, spanning ∼1000 km of the south-to-north (27° to 24° S) natural rainfall and ecosystem function gradient that spans the arid to hyperarid transition (from 20 to <1 mm rainfall y-1). Localities include the well-characterised Yungay desert research station, initially declared as the driest place on Earth beyond the limit for microbial life (McKay et al., 2003). Importantly, our nitrate and perchlorate data confirm and extend suspicions that drier localities than Yungay exist (Azua-Bustos et al., 2015). For example, our "km40" site reveals 10 mg/kg of perchlorate at the surface, with a peak of 35 mg/kg at 10 cm depth. At "PONR", perchlorate peaks at >100 mg/kg at 120 cm depth, with an astonishing 22 mg/kg at the surface. In comparison, perchlorate peaks at ∼4 mg/kg at 90 cm depth in our Yungay soil profile. Given that perchlorate is the most soluble naturally-existing salt, "km40" and "PONR" indicate a complete lack of recent precipitation and are candidates for the driest place on Earth.

We use the numerical model of Marion et al. (2008) to quantitatively constrain the maximum rainfall distributions and event frequencies that are permitted by our measured profiles. Our Atacama soil profiles exhibit vertical variation in their geochemistry, suggesting considerable climatic and precipitation variability in recent years, enabling constraints on both maximum rainfall events and their temporal occurrence. Through geochemistry and modelling, this research identifies a unique quantitative palaeoprecipitation proxy for Earth's driest desert, with significant consequences for understanding and predicting the future ecohydrological cycle in desert ecosystems, as well as for the planet-wide desert on Mars.

References

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