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Geochemistry of the hydrothermal systems in the Jujuy Province, Argentina, and relationship with the regional geology

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The western sector of the Jujuy province (22°-24° S), Argentina, basically consisting of the Puna region (from 3,500 to 4,700 m a.s.l.) that borders the Central Volcanic Zone (CVZ), is characterized by sub-meridional ridges that alternate with elongated basins and by extremely voluminous intermediate and silicic ignimbrite deposits, the latter being related to late miocenic and pliocenic calderas and central volcanic edifices. In this region, several hydrothermal discharges with outlet temperatures up to 62°C occur. Among them, the Coranzulí and Pairique thermal emissions show a spatial relationship with miocenic volcanic complexes, whereas other thermal manifestations (Queñual, Orosmayo, Pirquitas, Arizutar, Cono Panizo and Rachaite) are clearly controlled by the local structural setting. Most of these thermal waters have relatively high total dissolved solids (TDS up to 46,500 mg/L), an alkaline-chloride composition and significant concentrations of B, NH4 and SiO_2, i.e. they show the typical geochemical features of geothermal brine. Exceptions are the Coranzulí, Orosmayo and Rachaite springs, mainly fed by a shallow Na(Ca)-bicarbonate aquifer.
The eastern sector of the province consists of the Eastern Cordillera, composed of a proterozoic basement constituted by the sedimentary sequences of the Puncoviscana Fm, and the Subandean Range, which shows wide east–vergence anticlines whose detachment levels are Silurian–Devonian shales. Both regions are separated by a major thrust that rises the Proterozoic and Eopaleozoic sequences over the Subandean System.
The thermal waters in the Eastern Cordillera, namely Termas de Reyes, are characterized by alkaline-sulfate composition, temperature of ≈50°C and neutral pH.
In contrast, in the Subandean Ranges, which is separated from the Eastern Cordillera by a thrust rising Proterozoic and Eopaleozoic sequences over the Subandean System, the Aguas Calientes springs are characterized by low temperature (from 21°C to 33°C) and a Ca-bicarbonate composition, with no significant evidences of deep fluid contribution.
In spite of the clear differences in water chemistry of the thermal waters from the two domains of the studied area, the chemical composition of the associated gas phases are invariably dominated by CO_2, with minor abundances of organic and atmospheric gases. The carbon isotopic signature of CO_2 is consistent with that typically found in hydrothermal fluids, i.e. with significant contribution from a crustal source. Nevertheless, the R/Ra values indicate a significant fraction of mantle He (up to 17%). and the CO_2/3He ratios are 2.9×1012, up to three orders of magnitude higher than the MORB value.