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Monitoring of the low-enthalpy geothermal resource in southern San Juan province, Argentina

Espósito M. A. [1], Aguil Martínez N. [1], Pérez Luján S. B. [1] and Wohnlich S. [2]

[1] Centro de Investigaciones de la Geósfera y Biósfera (CIGEOBIO) - Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET). Facultad de Ciencias Exactas, Físicas y Naturales. Universidad Nacional de San Juan (UNSJ). Av. Ignacio De La Roza 590, San Juan, Argentina.
[2] Institut für Geologie, Mineralogie und Geophysik. Fakultät für Geowissenschaften. Ruhr-Universität Bochum. Universitätsstraße 150, Bochum, Germany.

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Abstract

This study focuses on the monitoring of low-enthalpy geothermal resources in the southern area of the San Juan Province, northwestern Argentina. To carry out groundwater temperature monitoring, four types of data logger sensors have been installed in soils and aquifer wells distributed throughout the study area. These devices record temperature, absolute pressure, and electrical conductivity over time. From July 2023 to the present, there are 10 active sensors in the Tulum oasis and surrounding areas, set with a measurement interval time of 10-minutes. In addition, water samples have been collected and in situ measurements of temperature, conductivity, and pH have been taken; for hydrochemical and isotopic analysis. Preliminary results indicate that groundwater temperature increases southward, reaching 32°C, and showing a correlation with geological structures. On the other hand, the piezometric levels exhibit a negative trend of up to 3 meters in the measured period. All the information collected in this study will provide the basis for assessing the geothermal potential of the region and for monitoring the water resources.

1. Introduction

The study area comprises the south of the San Juan province, located in northwestern Argentina (Fig. 1). This region, traversed by the South American Arid Diagonal (De Martonne, 1935), is characterized by extreme aridity, high temperatures, and a strong water deficit (<100 mm/year; Suvires & Luna, 2008). The presence of mountain ranges and extensive intermountain valleys dominates the landscape of the area, including the Tulum Valley, which supplies water and soil to the San Juan city and surrounding areas, where the main agro-industrial activities take place and where the highest population density in the province is found (INDEC, 2024).

The growing expansion of San Juan's principal city and the energy demand generated by new economic and industrial sectors in the region, promote the need to look for new environmentally friendly alternative energies to help supply this consumption. Low enthalpy geothermal energy, found at shallow depths throughout the Earth, could become an important alternative source to reduce electricity demand and contribute to environmental protection in the northwestern region of Argentina. In the southern portion of the Tulum valley, much of this important energy resource is strongly linked to the groundwater stored in the aquifers, which have anomalous temperatures compared to other areas of the valley. However, continuous records of historical data on piezometric levels and temperatures in the Tulum aquifers are very scarce and sometimes non-existent.

In this context, this study focuses on the constant monitoring of both water and geothermal parameters of the aquifers in the southern portion of the province of San Juan in order to understand their behavior, evaluate their geothermal potential and propose ideas to use them as a sustainable energy source in the immediate future, as well as to implement measures to protect and manage them in an efficient and sustainable way in the current context of water crisis.

Fig. 1: Location of the study area in San Juan province. In the upper left margin, a picture of the location of the San Juan province in Argentina.

2. Objective

The objective of this work is to contribute to the knowledge of the geothermal potential of the southern sector of the San Juan province through the survey of thermal manifestations, their hydrochemical and isotopic characterization, estimation of the source temperature and the geological-geophysical analysis of the structures that control the geometry of the basin and aquifer levels of the study area. For this purpose, a database will be generated for constant monitoring of temperature and piezometric levels throughout the study sector.

3. Methods

For this study, the potential thermal anomaly zones in southern San Juan province were strategic selected using a database reported by the Instituto Nacional del Agua - Centro Regional de Aguas Subterráneas (INA-CRAS). Four types of HOBO data logger sensors have been installed in soils and aquifer wells with a measurement interval time of 10-minute (Fig. 2). These devices record temperature, absolute pressure and electrical conductivity over time (Fig. 3A - 3D). For the process, barometric corrections were applied, consulting the meteorological database reported by the Servicio Agrometeorológico Estación Experimental San Juan (EEA-INTA). The compensated barometric pressure is then represented as piezometric levels by applying simple mathematical formulas. The obtained data are collected using a computer after a measurement period of approximately 5 months. In situ measurements (temperature, conductivity and pH) are also taken in each well with a sonic piezometric probe and a portable digital conductivity and pH meter (Fig. 3E). These instruments are calibrated prior to each measurement.
Furthermore, not only water samples have been taken from the hot springs for hydrochemical and isotopic analyses (Fig. 3F - 3G), but also representative rock samples have been collected from the

hydrogeologic basement for petrophysical analysis (Fig. 3H). These analyses are carried out in the laboratories of the Ruhr-Universität Bochum (RUB) and they are still in process.

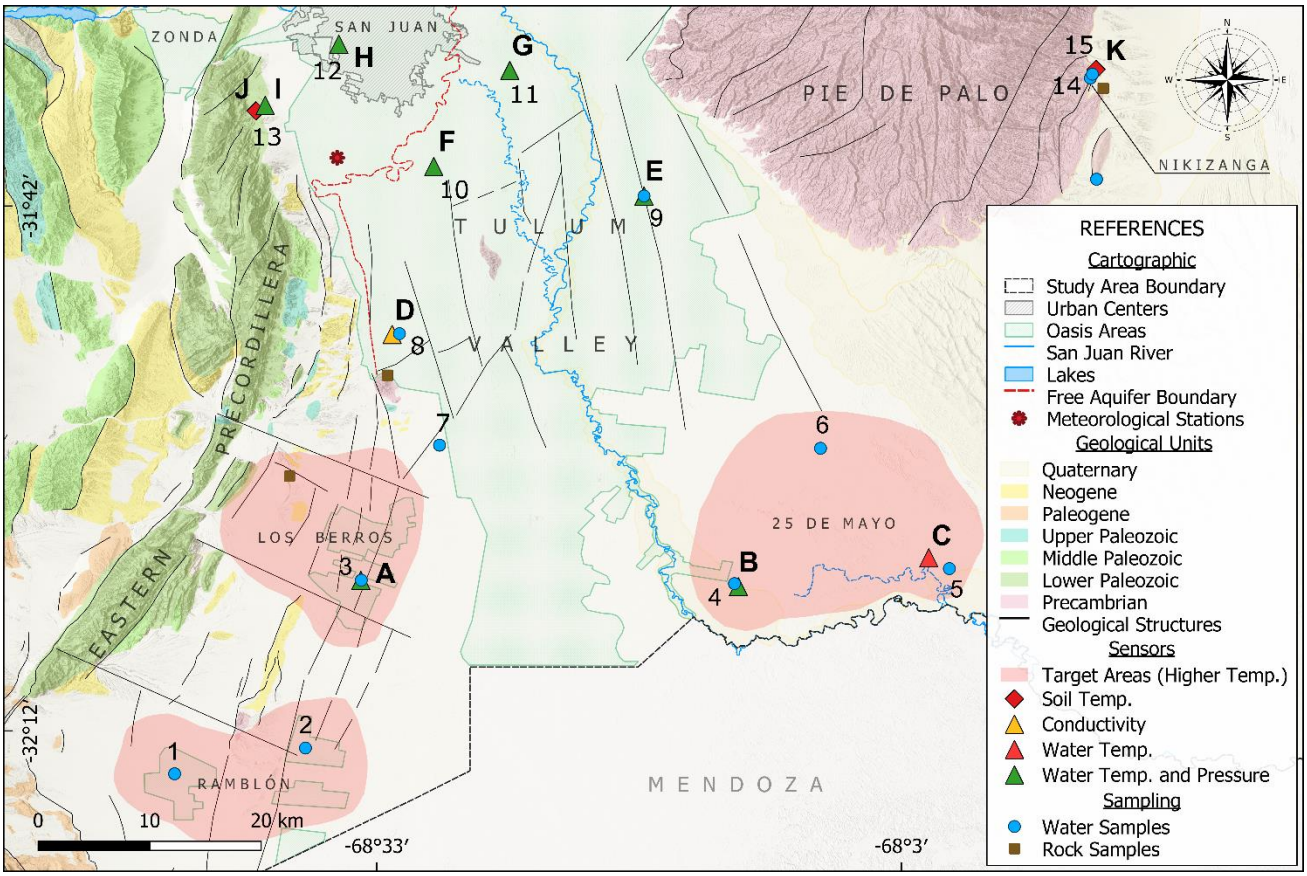

Fig. 2: Geological map with the location of the sensors installed in the study area. Compilation of structures taken from Zambrano & Suvires (2008) and Ramos et al. (2000). The boundary between the free aquifer (left of the red line) and the semi-confined and confined aquifers (right of the red line) used in this work is that reported by INA-CRAS. The numbers indicate in situ temperature measurements.

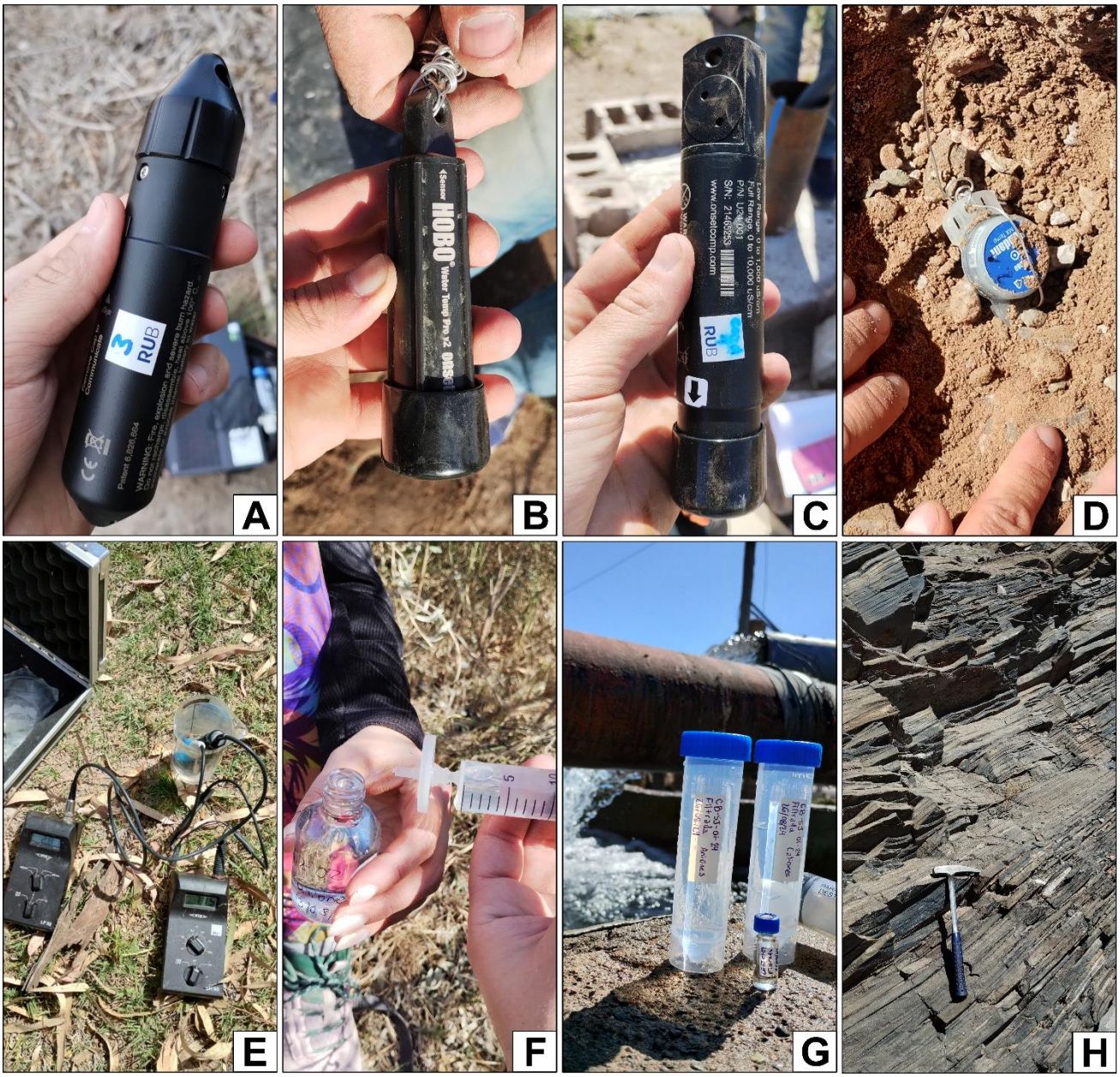

Fig. 3: Methodology followed in this research. A) Aquifer temperature and pressure data logger sensor; B) Aquifer temperature data logger sensor; C) Aquifer conductivity data logger sensor; D) Soil temperature data logger sensor; E) Multiparameter equipment for T, conductivity and pH measurements; F) Water sampling procedures; G) Water samples; H) Rock sampling procedures.

3. Results

3.1 Temperatures

Sensor measurements results indicate that temperatures are constant over time, showing almost no seasonal variations (Fig. 4). However, since most of the wells in the study area pump constantly, the temperature behavior shows a relationship with the pumping rate.

Besides, data from in situ temperature measurements in the Ramblón wells area indicate temperatures higher than 29°C, while in 25 de Mayo area they may exceed 31°C (Fig. 4 and Table 1).

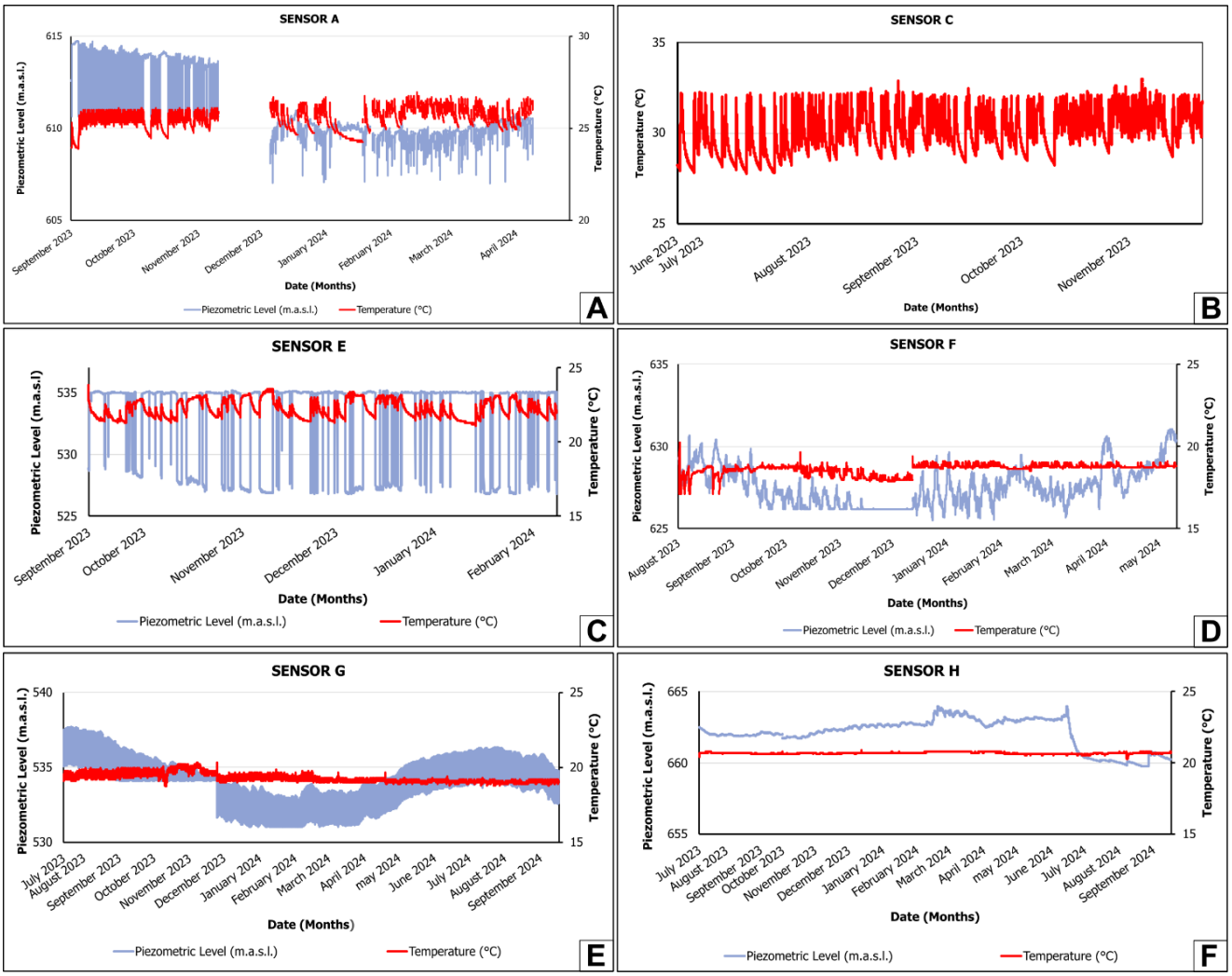

Fig. 4: Results from different types of sensors implemented in the study area. A) Sensor A; B) Sensor C; C) Sensor E; D) Sensor F; E) Sensor G; F) Sensor F.

ID	Measurement date	Temperature
1	23/8/2024	25.1°C
2	23/8/2024	29.9°C
3	23/8/2024	26.0°C
4	23/8/2024	31.5°C
5	8/6/2023	32.4°C
6	26/8/2024	29.4°C
7	23/8/2024	23.6°C
8	21/8/2024	20.6°C
9	26/8/2024	21.1°C
10	9/10/2023	21.0°C
11	13/9/2023	19.2°C
12	19/4/2024	20.8°C
13	17/4/2023	27.4°C
14	13/8/2024	23.9°C
15	13/8/2024	25.0°C

Table 1: Summary of in situ temperature measurements in southern San Juan province.

3.2 Piezometric Levels

The analysis of the piezometric levels in the Tulum semi-confined and confined aquifers show a negative trend from July/August to April and a positive trend from April/May to July, while the piezometric levels in the Tulum free aquifer from December/November to June/July exhibit a positive trend and a negative trend from July to November (Fig. 4). In addition, it can be observed that the strong variations in the piezometric level are related to the intense pumping of the wells, which usually increases during the summer/spring season.
It should be noted that sensors B, D, I, J and K (Fig. 2) are still recording new information and preliminary results are only available.
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4. Conclusions

The following conclusions can be drawn from preliminary results: 1) The groundwater temperature increases southward, reaching 32°C. In situ measurements indicate that aquifer temperatures in the south are higher (>25°C) than in the center-north of the study area; 2) There is a correlation with geological structures. First-order structures reported by different authors could act as pathways for the ascent of higher temperature fluids; 3) These data indicate that the study area has a low-enthalpy geothermal potential. Based on this, potential areas where temperatures exceed 25°C have been defined. The high temperature areas could be potentially used by the community in the future for balneology purposes, application in air conditioning/heating systems for houses and greenhouses, in the production of sanitary hot water, among others; 4) On the other hand, the trend of piezometric levels in the Tulum aquifers is generally negative from July to December and positive from February to June, showing a seasonal behavior with recharge in the main rainfall months (December, January and February). However, piezometric levels fall by more than 3 meters in the measured periods, mainly in the semi-confined and confined aquifers.
Since this study is the first with continuous data in the province of San Juan, it could help in the future to define potentially exploitable areas to take advantage of low enthalpy geothermal energy in the south of the province of San Juan and to manage and make decisions about water resources in the context of the water crisis.

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