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Revitalizing Geothermal Records: Comprehensive Filtering of Historical Pressure and Temperature Well Logs in El Salvador's Geothermal Fields

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ABSTRACT

The geothermal fields of El Salvador have been monitored through pressure and temperature (PT) logs since the 1960s to track variations in thermodynamic properties over time. In the early years, mechanical tools were used for wellbore logging, leading to inconsistencies such as unexpected deviations, abrupt trend changes, and values dropping to zero due to equipment failures or human errors during manual data transcription. To address this challenge, this paper proposes a tool for the optimal correction of approximately 5,000 records and the update of the historical database of well logs by integrating Python and SQL. This approach enhances the management and utilization of geothermal data in LaGeo by optimizing well-life records, which are crucial for the efficient operation of geothermal power plants and the accuracy of technical analyses. Ultimately, this contribution aims to improve the sustainability and efficiency of geothermal energy production in El Salvador by providing reliable reference data on well lifespans.

INTRODUCTION

Geothermal energy represents a strategic resource for sustainable electricity generation. Situated within the Pacific Ring of Fire, El Salvador benefits from a highly active volcanic landscape that is well-suited for geothermal exploitation [2]. This work addresses a critical challenge in geothermal data management: the correction and optimization of historical PT well log records. Over decades of operation, LaGeo has accumulated thousands of PT measurements across multiple geothermal fields in El Salvador. During a six-month professional internship at the Reservoir Engineering Department of LaGeo, a comprehensive data refinement process was developed and implemented. This initiative is focused on standardizing 4,884 PT records from LaGeo's Geothermal Management System (GMS database) through automated analysis, validation, and correction using Python and SQL [4][5], restoring data usability and reinforcing technical decision-making, reservoir modeling, and geothermal field sustainability [6].

METHODOLOGY

Through the employment of three custom Python scripts, the project retrieved, visualized, compared, and corrected historical PT records from LaGeo's GMS database. The process involved: (1) extracting original records via SQL queries [5], (2) identifying anomalies through graphical analysis [3], and (3) applying logical filtering rules to correct data inconsistencies. Unrealistic values—such as abrupt discontinuities or zero readings at non-zero depths—were nullified. Python libraries such as Pandas [4], Matplotlib [3], and IAPWS97 were utilized, while SQL operations were executed using SQLite Studio [5]. All corrections were stored in a replicated version of the GMS database and annotated for traceability.

RESULTS

From the 4,884 historical PT logs analyzed, 1,035 were identified as containing anomalies requiring correction. The most frequently observed issues included temperature or pressure values dropping to zero at surface level, irregular fluctuations likely resulting from sensor malfunctions, and repeated values at consecutive depths, which produced stair-step patterns in the graphical profiles. To systematically address these inconsistencies, all faulty records were categorized into six distinct correction cases, each defined by the type and severity of the anomaly. A total of 1,032 records were successfully corrected using the developed Python scripts and filtering logic, while three entries were discarded due to irreparable identifier corruption that rendered them unverifiable within the dataset. The implementation of these corrections significantly improved the consistency and integrity of LaGeo's geothermal well log database. This enhanced data quality directly contributes to more accurate reservoir modeling [1], supports operational planning, and reinforces evidence-based decision-making processes for geothermal field management [6].

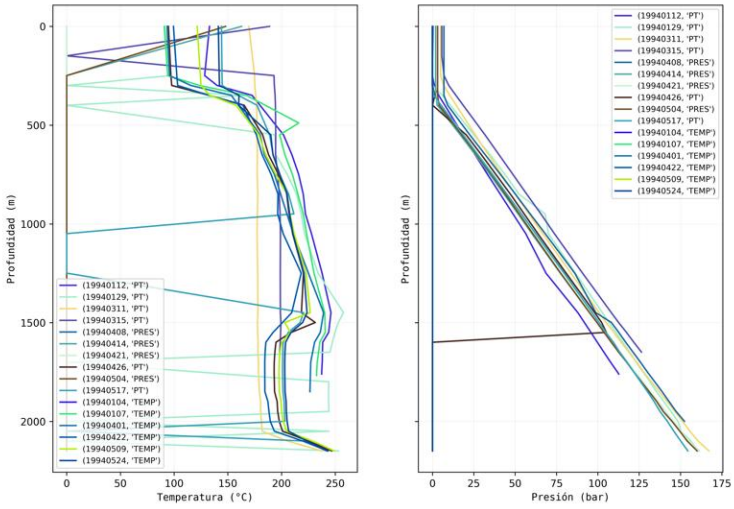


Figure 1. Original PT logs in Well TR-9 (1994) [7].

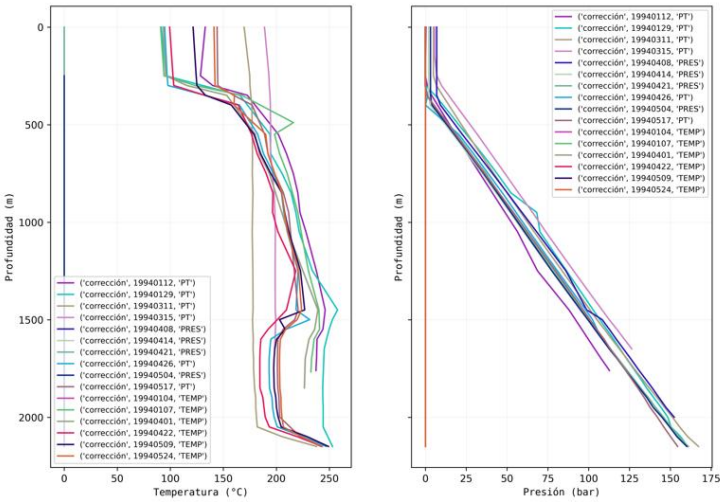


Figure 2. Filtered PT logs in Well TR-9 (1994) [7].

DISCUSSION

The application of automated Python scripts, in conjunction with structured SQL queries [5], substantially minimized the manual workload associated with cleaning decades of historical well log data. This approach enabled a scalable, repeatable workflow for identifying and correcting inconsistencies across thousands of records. By integrating the refined data into LaGeo's operational systems, the project not only enhances the reliability of geothermal datasets [6] but also supports long-term sustainability efforts. Engineers and analysts can now base their technical assessments and reservoir management strategies on accurate, consistent, and traceable information, thereby improving the overall efficiency of geothermal field operations [2].

CONCLUSIONS

1. The implementation of automated data correction workflows using Python and SQL proved to be a robust and scalable solution for addressing inconsistencies in historical PT well logs. This approach significantly reduces manual processing time while maintaining data integrity.
2. The refinement of 4,884 PT records enhances the technical value of LaGeo's Geothermal Management System, providing a more reliable foundation for reservoir modeling, performance analysis, and operational decision-making.
3. The methodology developed through this project is transferable and can be adapted for similar legacy datasets in geothermal or other energy sectors, where long-term data quality is critical for resource planning and sustainability.

4. By integrating corrected datasets into the company's operational infrastructure, LaGeo strengthens its capacity for evidence-based geothermal field management, contributing to the efficiency, safety, and environmental responsibility of its operations.

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