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GEO-NETWORK OF LATINAMERICAN-GERMAN ALUMNI (GOAL)

CONTENT

1. Nota del Coordinador Regional

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El presente año marca una especie de referencia en el desarrollo de GOAL, toda vez que nos acercamos a cumplir 20 años de vida!!! Durante este tiempo la red ha contribuido al desarrollo de las geociencias y al acercamiento profesional entre 14 países latinoamericanos y Alemania. Los seminarios-talleres que se han realizado en siete países (Perú, Chile, Ecuador, Alemania, Costa Rica, Brasil, Colombia y México) han sido un medio expedito para difundir y debatir avances en investigaciones de nuestros campos de acción, con efecto directo en la academia, en organizaciones técnicas y en la empresa privada, según sea la actividad de los miembros.

El boletín de GOAL ha sido, sin duda, un vivo ejemplo de difusión del conocimiento, que se ha nutrido de valiosos aportes provenientes del interior de la red, así como de significativas contribuciones externas. Con éste, ya se llega a una veintena de números que, con el futuro y continuo aporte de ustedes los miembros, seguirá cumpliendo su objetivo a cabalidad.

Un tema recurrente en estos casi dos años ha sido, tristemente, el de la situación crítica de salud mundial, la cual ha cambiado nuestra cotidianidad en prácticamente todos los aspectos. Por tal razón se ha aumentado la comunicación a otros niveles (plataformas en línea), como la empleada en las reuniones virtuales de GOAL, celebradas durante el primer semestre de 2021. Sin embargo, tal como lo anotó Martín en su nota editorial pasada, las conferencias virtuales no reemplazan las reuniones presenciales.

Bajo esta perspectiva, y con la aplicación de un prudente optimismo, se espera una respuesta positiva de parte del DAAD en relación con nuestra propuesta de seminarios-talleres para los dos años siguientes, Alemania-2022 y Cuba-2023.

Mis votos porque el año que pronto comienza esté a la altura de sus expectativas en todo sentido.

2. Promoting geothermal heat for (agro-) industrial processes

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Due to its location on the Pacific Ring of Fire, Central America has very distinct geothermal resources. The viable geothermal potential of the region is estimated at 3 to 5 gigawatts. About 650 megawatts have been used for electricity generation and only 7 MW are used for direct use purposes. There are immense opportunities to use geothermal energy directly for industrial applications, such as for drying fruit and seeds, heating greenhouses or cooling warehouses, storage rooms and buildings.

In March 2021, the regional project, "*Geothermal Heat Utilization for Industrial Processes in the SICA member countries*" (GEO II), commissioned by the Federal Ministry for Economic Cooperation and Development (BMZ), signed a Memorandum of Understanding with the International Geothermal Association (IGA). The collaboration aims at examining and strengthening geothermal direct use activities in the eight member countries of the Central American Integration System (SICA).

In August 2021, representatives from IGA and the GEO II team realized a first technical visit to El Salvador and Honduras. The trip included a visit to *Berlín*, the geothermal field from the government owned enterprise LaGeo in El Salvador. LaGeo generates almost 25% of the country's electricity by geothermal sources. In Honduras, the representatives, accompanied by the German Embassy, visited projects, such as a little cheese production company in Pavana, Choluteca and a salt industrial plant. Both have the potential to scale up their production by using geothermal heat.

Figura 1. Local cheese producer in Honduras has potential to use geothermal for a pasteurization process.

GIZ and IGA will foster its collaboration on geothermal energy to bring efficient and innovative technologies to Central America.

Showing a regional experience

GEO II started in November 2020 with a duration of three years. The project has the goal to improve the conditions for industrial geothermal direct use applications in the eight SICA member countries (Fig.2). According to this objective the project is committed to transform the region into a platform of opportunities to show the world the local experiences and the enormous geothermal potential that can be ecologically friendly exploited.

The project is focused in four intervention areas: (1) Legal framework conditions, (2) Demonstrative projects, (3) Methods and Instruments and (4) Exchange of professional experiences. At the same time GEO II has identified at least six potential synergies between the industry and the geothermal direct uses:

1. **New opportunities to enhance competitiveness:** Involvement in regulatory framework processes with the public sector and to be the "Voice" of the consumer.
2. **Geothermal energy and green recovery:** Awakening interest in new businesses and strengthen local companies.
3. **New services for chambers:** Training, consultancy and technical assistance in geothermal energy and its direct uses (for instance tools for decision making).
4. **Cooperation opportunities:** DeveloPPP, public-private partnerships between the German Cooperation for Development and private companies.
5. **Professional Exchange:** Local, regional and international cooperation with experts in the geothermal field for strategic events and activities.
6. **International networks:** Match making opportunity to get closer to new networks of contacts in the geothermal world and the private sector.

The GEO II project is the successful continuation (second phase) of the geothermal cooperation project in the region, which already started in 2016. The vast experience of the work in the first phase, so called *Promotion of Geothermal Energy in Central America* (FoGeo), supported the follow-up *Use of Geothermal Heat in Industrial Processes in the Member Countries of SICA* (GEO II) with emphasis on geothermal direct uses in (agro-)industrial processes. It strengthens projects, which give an opportunity for local development with a sustainable approach.

Figura 2. Geo-II. A group of women working inside LaGeo geothermal field as part of social program.

3. RoBiMo-Trop – or how do we enable reliable gas exchange determinations over water bodies?

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When you read this, people have gathered in Glasgow at COP 26, aiming at negotiating improved actions to mitigate climate change. While I have a hard time to trust in reaching the 1.5 degrees Celsius target, I still do hope that we could make the 2-degree target. That will be tough enough, given our sluggish progress over the years since COP 15 in Paris.

From a merely scientific perspective, there are enough open questions that await smart answers. One of them relates to the role of water bodies in the global carbon cycle. To which extend do freshwater bodies (2 percent of the continental surface) act as a source for greenhouse gases or as sinks? Most of the literature suggests that water bodies (including wetlands) are the strongest emitters of any single land-use type. There is non-conclusive information around, however – most of which from temperate climate zones, which may lead to bias. Yet, there is another important aspect: Lakes in the humid tropics undergo major water-level differences between the dry and the rainy season. These intra-annual variations may help to better understand current and future lake dynamics under climatic change, since there may be a significant difference in gas exchange behavior between those seasons.

In January 2020, we could launch the EU-supported project RoBiMo (https://tu-freiberg.de/en/robimo). The acronym stands for “robotic monitoring of freshwater bodies”. Based on our previous experience with mobile chamber systems for soil environments (e.g., EcoRespira-Amazon; https://blogs.hrz.tu-freiberg.de/ecorespira/), we further developed the idea and now have a modified system that works semi-autonomously on a floating platform (Figure 1).

Figure 1. Field campaign RoBiMo-Trop, September-October 2021

The platform is highly versatile to carry different payloads upon demand, such as 3D-water body mapping with sonar, depth-simultaneous hydrographical profiling, micro and nano-plastics determination, and gas exchange measurements with our chamber system (Fig. 2). In parallel, micrometeorological data such as wind speed, air temperature and humidity are logged in parallel to highly precise depth-sounding and GPS-positioning.

Figure 2. The multiparameter probe ready for a hydrographic profile

Given the bias addressed above, we were able to attract funding from the German Federal Environmental Foundation (DBU) and the International Office (IB) of the German Federal Ministry of Education and Research (BMBF). This support enables testing our platform and its payloads in one of the most demanding tropical environments, the Amazon basin.

In September and October 2021, we could launch the first field campaign in Amazonas State, Brazil. Jointly with our long-term partner EMBRAPA, the Brazilian Agricultural Research Corporation, we successfully selected and targeted four different types of water bodies. The Balbina reservoir, about three hours north from Manaus, is a very large artificial blackwater lake. It has been studied since its construction in the early 1980's by various Brazilian and international researchers, especially Bruce Forsberg from INPA, the National Research Institute for Amazon Studies (Fig. 3). This lake system serves as reference body, given available data and known boundary conditions. The clear water with maximum depth around 30 meters (dry season) offers remnant large dead tree trunks; ideal to keep our boat and platform firmly positioned even with permanent wind shear.

Figure 3. Setting up the gas flow measurements on the Balbina reservoir

Our next stops were around the town of Rio Preto da Eva, an area with extensive fish-farming (aquacultures). Here we started to study basins for hatchlings as well as those for fattening the grown-up fish. These water bodies are completely detached biochemically from the surroundings, the only link remains the inflow of natural freshwater. Yet given the high density of fish in the basins, the waters are highly eutrophied. The opposite is true for natural blackwater and whitewater lakes and their environments (igapó and várzea). There, oligotrophic conditions prevail (Fig. 4). We studied four lakes on Iranduba peninsula, the landmass that separates the Solimões River from the Rio Negro River before their confluence downstream from Manaus; as of when we truly speak of the Amazon River. At all lakes, we also sample sediment cores in order to be able to describe their sediments and the respective carbon and nitrogen pools (amongst other parameters such as macro and micro nutriets (Fig. 5).

Figure 4. Island in the Balbina reservoir with dead tree giants

Figure 5. L. top: Who would have expected FC Barcelona on the banks of the Rio Solimões, whose vastness is hard to grasp (r. top); it is only a short way to Lake Iranduba with impressive dry cracks in the fertile mud (l. bottom), at the edge of which Docinho is getting his boat ready for us (r. bottom)

It is too early for more substantial conclusions in respect to our Amazon studies. We do however, see significant differences between the water body types both in respect to gas exchange and to the prevalence of dissolved organic carbon in the water column. Once all data from this first campaign are in and have been evaluated, we shall share the information with anyone interested. The results may be somewhat representative for dry season conditions. The next campaigns are being planned for March 2022 and rainy season conditions. We are already excited, also because our platform should then reach a higher level of autonomy (robotic driving).

Two sides of the same biome: the world of water and the world of forests

4. Geotourism and geopark potential from heritage in Biosphere Reserve Sierra Gorda at Victoria, Guanajuato, México

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The category of parks with unique natural elements on the surface and subsurface is called a Geopark (UNAM, 2020). These sites hold a geological diversity that contributes to biology, ecology, hydrology, archeology, and cultural elements. All these characteristics concern the Mexican government for spreading Earth Sciences and culture in general (SEMARNAT, 2017).

The Biosphere Reserve of Sierra Gorda includes part of the northeastern municipality of Victoria, in the state of Guanajuato in central-northern Mexico (Figure 1). Victoria offers sites of geological interest, early human settlements, an archeological site museum, other historical places, local knowledge for prime agricultural produce, and tracks for walking across the wild country. This region has natural wonders to explore and enjoy, resulting from volcanism and geological faults. The state of biological conservation and majestic peaks provide a vista for viewing surrounding highlands, gorges, and cliffs of the countryside. From the highest pass, the scene integrates valleys that nest and convey in the lower part.

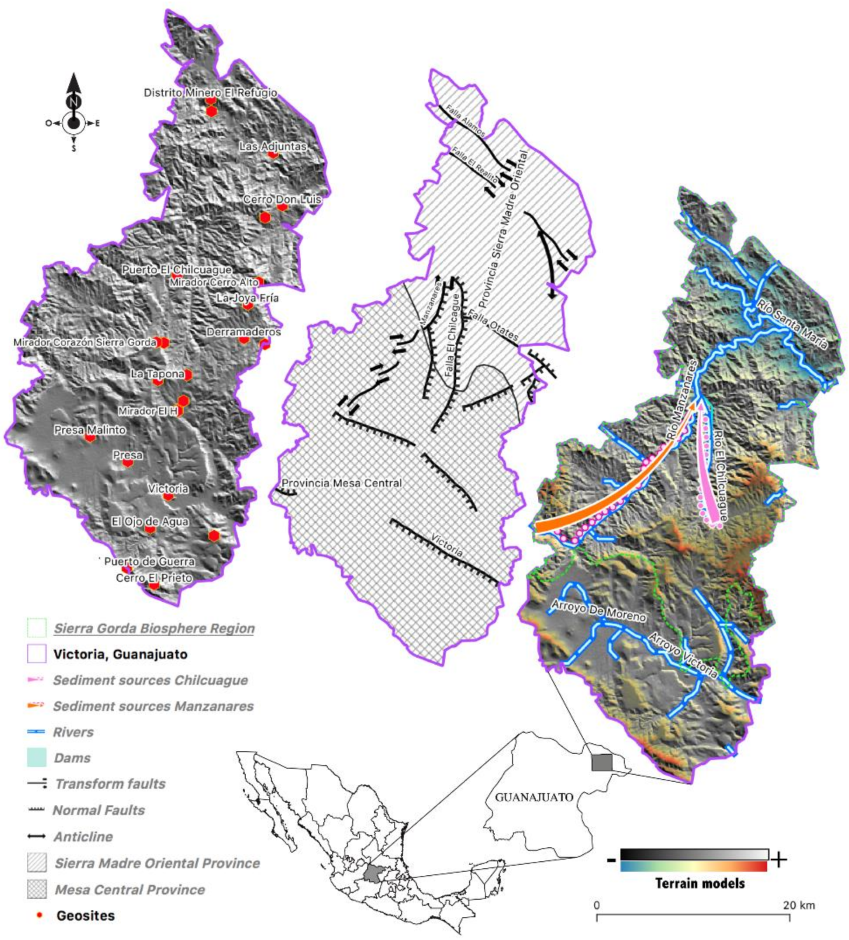

Figure 1. Map for Victoria in Guanajuato, Mexico, presenting the localities considered geosites; with a representation of the drainage network and source areas for sediments flowing through the geological structures in Mesa Central and Sierra Madre provinces.

The physiographic provinces of Sierra Madre Oriental and Mesa Central divide Victoria. The Mesa Central comprises vast plains interrupted by scattered hills, plateaus, or abrupt mountain ranges, primarily of volcanic origin. Meanwhile, the Sierra Madre Oriental province is in the extreme northeast of Victoria and the same as the Sierra Gorda subprovince area. The Victorian topography lacks of plateaus on the northeast, but slopes exceed 2,000 m.a.s.l (See Table). In the center and southwest, there are deep valleys alternated with mountain ranges following the outline of the geological faults.

Table 1. Geosites by zones in Victoria.

Geosites & geotourism
- southern -
Cerro El Prieto
Cerro El Puerto de Guerra
Cerro Grande
Chorro de Juana
Mina La Tapona
Mirador Las Higueras (2,411)
Peña de Cebada (2,318)
Puerto del Aire
- central -
Cerro Joya Fría
Mirador Las Casitas (1,987)
Mirador cerro Alto (2,196)
Mirador El Chilcuague (1,919)
Puerto Chilcuague (1,594)
Mirador Milpillas (2,163)
Mirador Yerbabuena (2,211)
Mesa Prieta, zona mineralizada
- northern -
Cerro Don Luis
Distrito minero El Refugio
La Onza, UMA*
Las Adjuntas
Arroyo Hondo, regenerative ranch (2,317)

Geosites by zones in Victoria.

Most high topography strikes are similar to fault orientation in respect to the north. Faults Victoria, Las Higueras, Otates, Mesa Prieta, El Realito, and Alamos are 130º; in contrast, faults Manzanares, Chilcuague, and Las Casitas have 10º to 30º with an approximate Oligocene age (Figure 1). Near the faults are the remains of mining operations for extracting ore deposits by oxidation and fluorite (localities of Cerro Don Luis, El Refugio).

Rocks from the Sierra Madre Terrane are underlying the younger Rio Santa Maria Volcanic Field, leaving Lower Cretaceous rocks as the oldest exposures in the surface (Figure 2). The interpretation of faulting and mineral deposits indicates the following geologic events above the Mesozoic basement (200 Ma): accumulation of Paleogene continental deposits (66 Ma), formation of a volcanic group in Eocene (56 Ma), generation of rhyolite domes (32-29 Ma), ignimbrites (29-24 Ma), basalts (13-8 Ma), Neogene continental sedimentary deposits interfingered with ignimbrites and basalts (last 10 Ma), and finally volcanic rocks slightly older than one million years old (Pleistocene).

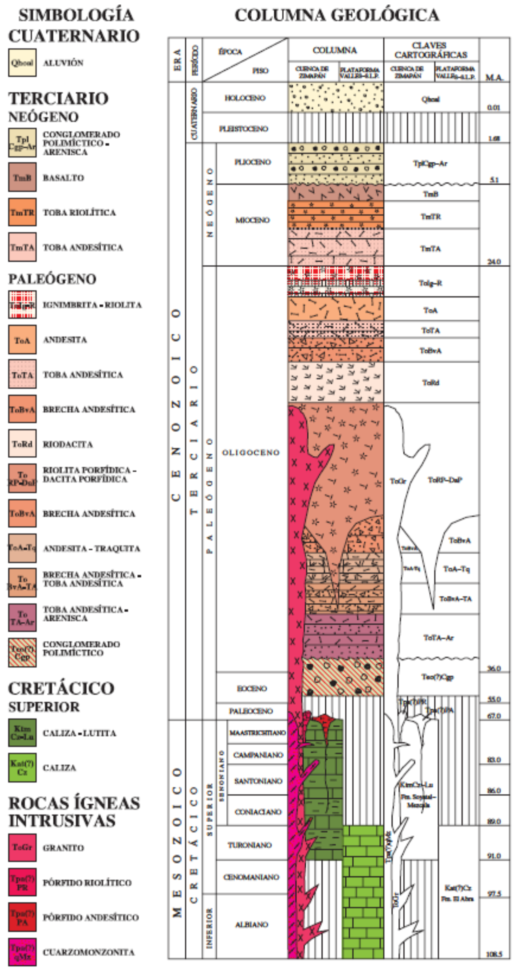

Figure 2. Stratigraphic column retrieved from the maps of Servicio Geológico Mexicano: F14-C26, F14-C35, F14-C36, and F14-C46 scale 1:50,000.

The surface watershed basins of Lerma Santiago and Pánuco are the units and natural limits for managing the geographic attractions to develop tourism in Victoria. The mineral wealth upstream in slopes surrounding the basins and earth dams distributed downstream valleys makes agriculture possible to thrive with geology into common tourism (dam localities El Bordo Viejo, La Presa El Nogalito in El Malinto, Misión de Arnedo, Rancho Arroyo Hondo, Presa de Palotes). These constraints also help for connecting geology to the produce and ranching activities. This way of management allows geoparks and artisanal agriculture to coexist in space for ecotourism.

In the locality of Las Adjuntas tributaries join. The site is considered essential for sediment accumulation and sorting mineral diversity for good soil fertility and agricultural yields. At that point, the flows of the Chilcuague and Manzanares rivers unify with the Santa María River downstream to the Pánuco basin, creating a tapestry of colorful sediments and rock fragments (Figure 3). The varieties of detritus in the alluvial plains indicate the many rocks eroded upstream and deposited downstream. The Manzanares River is cut by faults Las Casitas and Las Higueras, while the Chilcuague River origins from tributaries in the Otates and Derramaderos faults. Sediment on the river of each fault correlates to the sedimentary sequence of the Sierra Madre Oriental or the volcanics in Mesa Central. Due to its proximity to the Sierra Madre Oriental, the Chilcuague River concentrates higher limestone fragments, contrary to the predominance of volcanics in the Manzanares River.

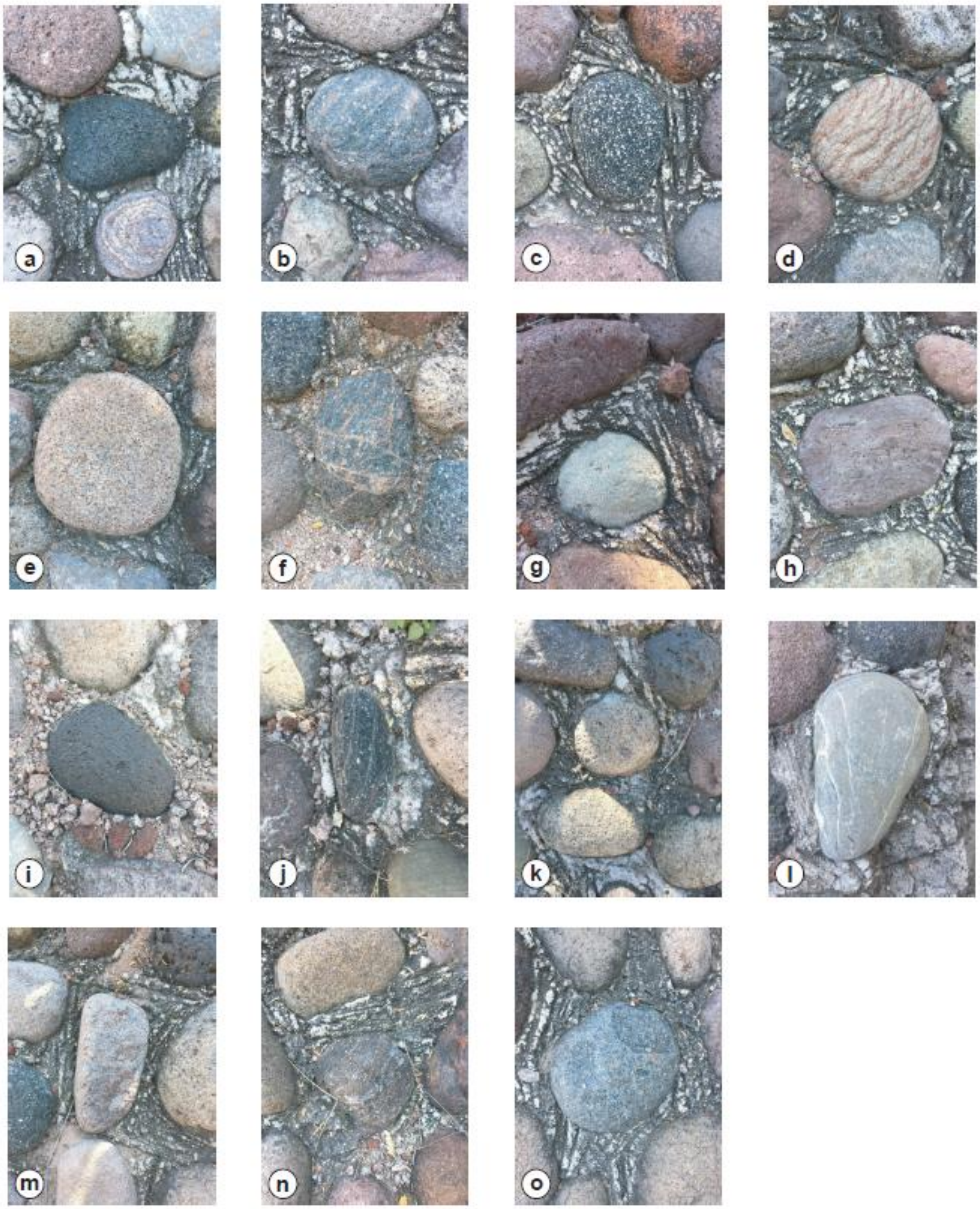

Figure 3. Rock fragments collected dowstream Chilcuague and Manzanares rivers (Rancho El Encanto): a. Basalt; b. Granite, porphyritic texture; c. Diorite; d. Granite, andesite porphyry?; d. Granite; e. Ignimbrite; f. Granite; g., Trachyte; h. Rhyllolite; i. Basalt; j. Granite; k. Ignimbrite; l. Limestone; m. Granite; n. Sandstone; o. Granite.

Another peculiar site is at the center-east end of the municipality. The water from the Chorro de Juana in Derramaderos, descends through La Pileta River, over the Derramaderos Fault, with runoff from West to East. These two geological touristic examples from Victoria deserve attention for didactic purposes, to explain how the different forms of relief, natural resources, and minerals make the constituents for produce. The provenance of sediments can guide visitors in understanding how a natural process of mineral transport by a river is necessary to maintain fertile soil. Both stories are preliminary, and supplementary scientific methods must explain this interpretation (Figure 1).

Victoria is a candidate for sustainable tourism and recreation in a natural protected area with valuable geosites. Although complex the entitlement of a geopark (UNESCO, 2020), an ordinary tourist can link the historical foundation of Victoria to natural landscape processes and human occupation, guiding tourism with destinations related to watersheds and mineral deposits. These touristic services can uplift the community in Guanajuato, ensuring some Sustainable Development Goals (i.e., #8: Decent work and economic growth; #13: Climate action; #17: Partnerships for the goals; UNESCO).

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References

SEMARNAT, 2017, Geoparques de México, territories de importancia geológica, viológica, ecológica, hídrica, arqueológica y cultural. Gobierno de México.

UNESCO, Global Geoparks, Top 10 focus areas of Unesco Global Geoparks.

UNESCO, 2020, Self-Evaluation Checklist Explanatory Notes For aspiring UNESCO Global Geoparks (aUGGp). 22 p.

UNAM- Dirección General de Divulgación de la Ciencia, 2020, La UNAM te explica: ¿Qué es un Geoparque? EcoPUMA: fundacionunam.org.mx

5. Arsénico en sistemas geotermales de Perú

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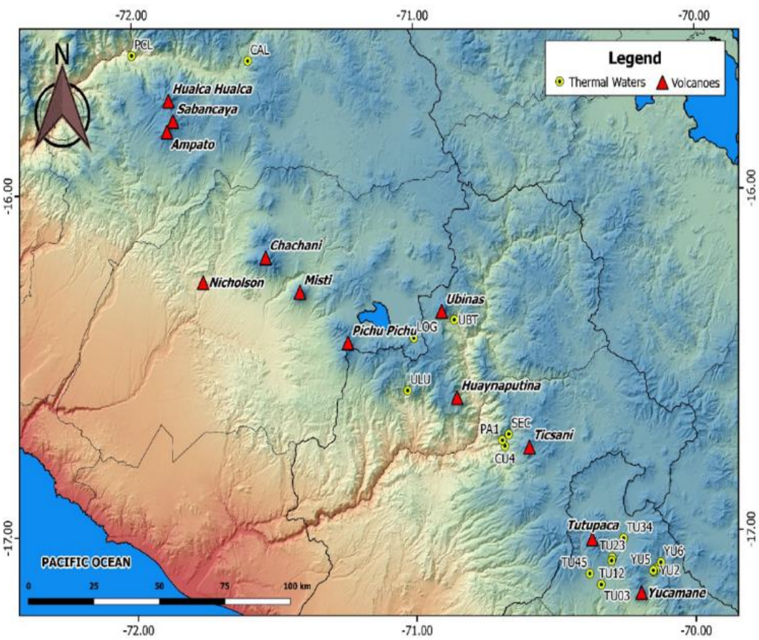
Perú está ubicado a lo largo del Cinturón de Fuego donde el proceso de subduccion ocurre entre las placas tectónicas de Nazca y Sudámerica. El país cuenta con un alto potencial geotérmico caracterizado por varias manifestaciones geotermales como fuentes termales, fumarolas y geysers. Dos regiones geotérmicas caracterizan Perú: el sistema geotérmico en la región norte controlada por un alto gradiente geotermal y la región geotérmica en el sur del país relacionada a una gran cantidad de centros volcánicos. Este estudio esta enfocado en el muestreo y análisis de fuentes termales en la región sur, la cual se caracteriza por varios centros volcánicos activos de edad Quaternario. Los volcanes mas importantes están ubicados en la región de Arequipa (volcán Sabancaya), Moquegua (los volcanes Ubinas, Haynaputina y Ticsani) y Tacna (el volcán Tutupaca y Yucamane). Con base a análisis de fuentes termales estas regiones volcánicas presentan una concentración de arsénico (As) que varía entre 0.17 a 111.1 mg/L, pH de 2.7 a 7.6 y temperaturas entre 27 y 94 ºC (Morales Simfors et al., 2020), superando el estándar establecido de 0.01 mg/L para aguas superficiales y subterráneas para consumo humano definido por la Organización Mundial de la Salud – OMS (WHO, 2003). De acuerdo a INGEMMET (2016), 1 8000 000 personas habitan entre las regiones de Arequipa, Moquegua y Tacna (INGEMMET, 2016). El problema de aguas superficiales y subterráneas contaminadas con As es conocido en más de 70 países (Jean et al., 2010), causando su consumo serios problemas de salud. El Antimonio (Sb) está también presente en estas regiones y generalmente es encontrado junto con As rio abajo y en las zonas de interceccion entre dos ríos o una fuente termal y un río.

Este resumen es en parte una compilación del proyecto realizado por la UNESCO Chair on Groundwater Arsenic con sede en la Universidad del Sur de Queensland, Australia entre el 2018 y 2021. Mas información al respecto ver Morales-Simfors et al., 2021; Bunsdchuh et al., 2021.



Sistemas geotermales en el sur de Perú: Sabancaya (Arequipa region), Ubinas, Huaynapatina, Ticsani (Moquegua region) and Tutupaca, Yucamane (Tacna region).

Sistemas geotermales en el sur de Perú

Campo Geotermal Sabancaya (Arequipa): El volcán Sabancaya esta rodeado de un sistema de fallas activas y lineamientos orientados E-W (Jay et al., 2015). Las fuentes termales mas importantes alrededor del volcán son Calera y Paclla (Tabla adjunta). En Calera las aguas son influenciadas por una intrusión andesítica, mientras Paclla es emplazado en el Canal de Colca de origen volcánico, cerca del río Colca, dando origen a uno de los valles mas profundos del país.

Campo Geotermal Ubinas (Región de Moquegua): Esta región es elongada en dirección NNW, sugeriendo que magma o un sistema de fluidos calientes sigue la dirección NNW. Fallas orientadas NNW-SSE han sido observadas en la parte superior de la cima de la caldera y flanco SSE del volcán, lo que puede indicar circulación de fluidos. Dos fuentes termales Ubinas y Logen (Tabla adjunta) fueron muestreadas alrededor del volcán Ubinas durante la campana geológica en el año 2017.

Volcán Huaynaputina (Región de Moquegua): En esta región las aguas termales de Ullucán están asociadas al volcán Huaynaputina caracterizado por varias fumarolas alrededor del cráter y aguas termales surgiendo alrededor del volcán. Este volcán es caracterizado por 4 sistemas de fallas y lineamientos orientados N-S, NW-SW, W-W y NW-SE. Los dos primeros sistemas están asociados con el río Tambo y el tercero y cuarto consiste en una serie de fallas transversas, paralelas a la Zona Volcánica Central de los Andes. Las aguas son posiblemente de origen magmático.

Volcán Ticsani (Región de Moquegua): Las principales manifestaciones asociadas con este volcán son Chuchumbaya, Putina Arriba y Secolaque. Esta región esta constituida por andesitas, dacitas, ignimbritas rioliticas y sedimentos. Dos fallas regionales han sido observadas en la zona, una en la dirección de los Andes NW-SE, NNW-SSE y WNW-ESE y la segunda en dirección NNE-SSW y NE-SW.

Volcán Yucamane y Tutupaca (Región de Tacna): En la región fueron analizadas 11 fuentes termales asociadas a ambos volcanes. El volcán y regiones aledañas están compuestas de andesitas, flujos piroclásticos asociados a domos de lava. Yucamane y otras estructuras volcánicas en la región de Tacna están muy fracturadas y alineadas en direción NW-SW controlando la circulación de los fluidos geotermales (Cruz et al., 2010; 2018).

En conclusión, la liberación y emisión de arsénico en el ambiente puede ser de origen geogénico o antropogénico. Ambos pueden impactar negativamente el ambiente y la salud humana. Arsénico puede contaminar el suelo, agua, aire y subsecuentemente puede entrar en la cadena alimenticia y causar serios problemas de salud. La contaminación del agua por As ha sido reportado en 200 áreas en 20 países Latinoamericanos (Morales-Simfors et al., 2020; Bundschuh et al., 2021). En el sur de Perú el promedio de As en 16 fuentes termales muestreadas por INGEMMET varía entre 0.17 a 11.1 mg/L (Morales-Simfors et al., 2020). Algunas de estas fuentes termales son usadas como agua potable o para los cultivos, así como modo recreativo para fuentes para baños termales lo que puede provocar problemas de salud a largo plazo.

Fuentes termales	Volcán	Temp. ⁰C	pH	As (mg/L)	Tipo aguas
Calera	Sabancaya	65.0	6.4	0.70	Na-Cl
Paclla	Sabancaya	93.7	7.6	1.42	Na-Cl
Ubinas	Ubinas	28.0	6.1	0.17	SO4-Cl-Na
Logen	Ubinas	30.8	4.2	0.40	SO4-Cl-Na
Ullucán	Huaynaputina	74	6.6	28.1	Cl-Na-HCO3
Chuchumbaya	Ticsani	49.5	6.2	2.5	Cl-Na-HCO3
Putina Arriba	Ticsani	90.0	7.3	3.29	Cl-Na- HCO3
Secolaque	Ticsani	71.4	6.8	2.170	Cl-Na- HCO3
Yucamane	Yucamane 6	83.2	6.6	11.1	Na-Cl-SO4
Yucamane	Yucamane 2	82.7	6.8	10.8	
Yucamane	Yucamane 5	nd	7.5	10	
Yucamane	Yucamane 1	67.2	7	9.6	
Yucamane	Yucamane 3	87.3	7	6.19	
Tutupaca	Tu34	86.9	7.7	4.8	
Tutupaca	Tu12	48.9	2.7	2.7	
Tutupaca	Tu23	61.1	2.6	2.3	

Referencias

Bundschuh, J., Schneider, J., Ayaz Alam, M., Khan Niazi, N., Herath, I., Parvez, F., Tomaszeweska, B., Guimaraes Guilherme, L.R., Maity, J.P., López, D., Fernández-Cirelli, A., Pérez Carrera, A., Morales-Simfors, N., Alarcón-Herrera, M.T., Baisch, P., Mohan, D., and Mukherjee, A. (2021). Seven potential sources of arsenic pollution in Latin America and their environmental and health impacts. J. of Hazardous Materias, 2021. https:/doi.org/10.1016/j.scitotenv.2021.146274

Cruz, V. (2018). Chemical and isotopic composition of hot spring waters in the Tacna region,Southern Peru. Techn. Rep. INGEMMET, Lima, Peru, pp. 1-16.

Cruz, V., Vargas, V., and Matsuda, K. (2010). Geochemical characterization of thermal waters in theCalientes Geothermal Field, Tacna, South of Peru. Proc. World Geothermal Congress, 25-29April 2010, Bali, Indonesia, Paper 330

INGEMMET (2016). Monitoreo de Volcanes Activos en el Sur de Perú. Retrieved from https://portal.ingemmet.gob.pe/web/guest/monitoreo-volcanes-activos.

Jay, J.A., Delgado, F.J., Torres, J.L., Pritchard, M.E., Macedo, O., and Aguilar, V. (2015). Deformation and seismicity near Sabancaya volcano, southern Peru, from 2002 to 2015. Geophys. Res. Lett.42, 8, 2780-2788.

Jean, J., Bundschuh, J., Chen, C.J., Guo, H.R., Liu, C.W., and Lin, T.F (2010). The Taiwan Crisis: a Showcase of the Global Arsenic Problem. CRC Press, Taylor & Francis group, New York, USA.

Morales-Simfors, N., Bundschuh, J., Herath, Indika, Inguaggiato, C., Caselli, A.T., Tapia, J., Erligtton Apaza Choguhuayta, F., Armienta, M.A., Ormachea, M., Joseph, E., and López, D. (2020) Arsenic in Latin America: A critical overview on the geochemistry of arsenic originating from geothermal features and volcanic emissions as an implication in environmental and human health impacts. Science of the Total Environment. https://doi.org/10.1016/j.scitotenv.2019.135564

WHO (2004). Guidelines for Drinking-water Quality. World Health Organization, Geneva, pp. 515.

6. International Scientific Events

XIV Congreso Geológico de Àmerica Central y VII Congreso Nacional de Costa Rica, 22-25 de marzo de 2022. Más información: http://14cgac.com/

Geo-Congress 2022, March 20-23, 2022. Charlotte, North Carolina. More information: https://www.geocongress.org/program/call-submissions

World Congress on Climate Changes and Ecosystem.April 21-22, Madrid, Spain. More information: https://climate.conferenceseries.com/

9 th International Conference on Geological and Environmental Sustainability, November 17-18, 2022, Rome, Italy. More information: https://geology.conferenceseries.com/

Felices FIESTAS y próspero 2022

Boas FESTAS e feliz 2022

Schöne FEIERTAGE und ein glückliches 2022

Happy HOLIDAYS and an abundant 2022

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