

Viewpoint

Voces Mineras: Clarifying the future of artisanal and small-scale mining collaborations



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ABSTRACT

Using a creative capacity building (CCB) framework, co-design workshops among artisanal and small-scale gold miners, government officials, NGO representatives, and academics can provide an effective mechanism to identify pressing needs and desires of miners and operators towards formalization. As recently implemented in Peru, one of these workshops identified the need for a single forum (association) to allow artisanal and small-scale miners to represent their voice in front of government and large-scale mining operations and the need for a streamlined simple process for formalization that included mining, environment, health, safety, and employment considerations. A first step towards the single forum was taken with the creation of a social media outlet that allows participants to voice their concerns and share information. Future workshops are needed to cement the creation of the forum and provide specific recommendations for the streamlining of the formalization process.

1. Introduction

In Peru, artisanal and small-scale gold mining (ASGM) lies at the center of discussions related to resource extraction. These discussions are often contentious because of illegal activities associated with ASGM, ASGM activities taking place in protected areas, and the large and growing informal and unregulated nature of ASGM operations. For years, government and development agencies have initiated efforts towards ASGM formalization, as well as transitioning miners away from mercury use in mineral processing systems and improving gold recovery methods. Although there is a clear recognition among communities and regulators alike that as it operates now, the sector is critical to rural livelihoods, there are concerns related to its sustainability as a viable livelihood and the associated environmental and social impacts.

Peru is currently the sixth largest gold producer in the world and the number one gold producer in Latin America (USGS, 2018). In 2018, approximately 60 % of Peru's exports were comprised of metals (such as copper, gold, lead, etc.) (MINEM, 2018). The exact number of artisanal and small-scale gold miners in the country is not well-established, but it is a growing sector, and estimates suggest that there could be anywhere

from 100,000–500,000 (De Echave, 2016). Artisanal and small-scale gold mining in Peru has expanded past the typical definition of a “low-tech, subsistence enterprise” (Cortés-McPherson, 2019). The sector represents a variety of labor, technology, and economic arrangements (Caballero Espejo et al., 2018), whereby some miners have become ‘elite’ small-scale gold mining entrepreneurs (Orozco and Viega, 2018; Cortés-McPherson, 2019) and are investing in larger and more sophisticated machinery and technologies while others maintain family-sized operations using traditional mineral processing methods. Given the growing and varied nature of the sector, there are significant concerns about the human health and environmental impacts of ASGM activities (Diringer et al., 2015; Gonzalez et al., 2019; Martinez et al., 2018; Wyatt et al., 2017).

In 2012, Peru created the Integrated Registry of Miner Formalization (REINFO), a database used to register miners who were in the process of formalizing. Since then, the registration process and database have gone through a number of iterations, but the government claims to have registered approximately 50,000 miners to date (REINFO, 2019). The majority of registered miners are from southern departments of Peru (Arequipa, Ayacucho, Puno, Apurímac, and Madre

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de Dios) and one department in the north, La Libertad (REINFO 2019).

Despite formalization efforts, many miners believe that their needs are not being addressed by the national government, and they continue to face barriers that prevent their growth as entrepreneurs and small-business owners, such as access to the right to mine and supply chain inequities. For example, it has been reported that up to 85 % of miners in the process of formalization are working on concessions of third-party owners and have yet to acquire the right to mine (Quispe, 2013). In addition, miners are often subject to powerful supply chain actors who control access to materials and markets (Smith, 2019). Even when artisanal and small-scale miners formalize, they receive very little government support to move away from mercury and implement cleaner technologies (Martinez and Smith, 2019). However, in general, miners want to improve and are willing to change their practices (Veiga et al., 2015; Smith, 2019; Smith et al., 2018; Pimentel et al., 2019).

A common narrative in the literature on ASGM and among development organizations speaks of the role of community capacity building in supporting more sustainable ASGM livelihoods (Hinton et al., 2003; Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development (IGF), 2017; Mutemeri et al., 2016; Stocklin-Weinberg et al. 2019). Examples exist on engaging ASGM communities to include educational and engagement initiatives using various forms of media (e.g. educational pamphlets, street theater, photography) tailored to specific demographics (e.g. age, gender, etc.) (e.g. Metcalf and Veiga, 2012; Spiegel, 2019). However, there are few examples of what community capacity building means or should look like and therefore, it remains a somewhat abstract concept. Therefore, this viewpoint provides an example of how universities, government, non-governmental organizations (NGOs), and ASGM communities can work together to build capacity within the ASGM sector. In this viewpoint, we report on a *Voces Mineras II* workshop held in Lima, Peru in April 2019 where miners, academics, NGOs, and government officials participated in a co-design workshop aimed at identifying challenges facing the ASGM sector in Peru and proposing practical pathways forward to address those challenges.

2. Background

Both regulatory (top down) and community capacity building (bottom up) activities must take place for a sustainable ASGM sector to develop and prosper. Although previous efforts have helped to inform local capacity among mining communities, many times their scope results in overarching generalizations or is geared toward specific environmental contaminants within ASGM, like mercury. In 1990, the United Nations Industrial Development Organization (UNIDO) implemented programs designed to develop local capacity to assess and minimize mercury emissions caused by ASGM (Spiegel and Veiga, 2005). These efforts resulted in the creation of the Global Mercury Project (GMP), supported by the Global Environment Facility (GEF), and the United Nations Development Programme (UNDP), in which capacity building among the ASGM sector was primarily directed at reducing mercury use and emissions. The GMP conducted a series of multi-stakeholder consultation activities in ASGM communities in 2005 and 2006 (Spiegel and Veiga, 2005). These activities included trainings and demonstrations in which experts disseminated information. Although efforts like these have made some progress in addressing ASGM challenges, they have often done little to identify activities or initiatives that would enhance local capacity to address these challenges. Therefore, ASGM operators and communities generally lack the resources, power, and opportunities to create a more sustainable path forward (Labonne, 2014).

3. Capacity building process

The *Voces Mineras II* organizers relied on input from leaders in national small-scale mining organizations to identify and recruit

participants. They also recruited participants from ongoing research projects in ASGM regions which some of the authors are involved. A multi-sector group committed to the sustainability of ASGM convened at Pontificia Universidad Católica del Perú (PUCP), Lima, Peru, on April 1–2, 2019 to participate in a co-visioning workshop on ASGM. The goal of the workshop was to build consensus on the main problems facing the ASGM sector in Peru and co-create approaches for solving these problems, thus enabling miners to effectively engage in regional and global markets and improve livelihoods. The workshop included representatives from 20 ASGM operations across the country, 4 regulatory jurisdictions, 2 international NGOs, 5 international universities, and several other organizations. Both formal and informal small-scale mining operations were strongly represented. Following a similar workshop in Colombia developed in 2018, the *Voces Mineras II* workshop used a creative capacity building (CCB) framework developed by Massachusetts Institute of Technology (MIT) D-Lab, previously used when working with informal sector workers but never in ASGM until now.

3.1. Participatory design framework

The workshop was organized by key investigators at PUCP, MIT, Colorado School of Mines (CSM), the University of Texas at Arlington (UTA) and Universidad Nacional de Colombia-Sede Medellín, all of whom have performed previous work together in collaborative participatory design in ASGM in various capacities. The workshop itself was built around five design teams, with minimal presentations in an effort to encourage participation from all stakeholders. Round table discussions on day one highlighted priorities from all attendee groups (operators, regulators etc.) and provided an in-depth review of critical challenges faced by artisanal and small-scale miners. Day two focused on co-designing practical routes for overcoming those challenges, resulting in the recommendations discussed below.

The CCB framework is based on a methodology of inclusive collaboration whereby all of the involved stakeholders progress through the design process to identify their own challenges and conceptualize approaches to solving those challenges that are relevant to their lives and communities. Previous results show the value of assisting stakeholders to design their own solutions (Hussain et al., 2012). The innovation in the CCB framework is not necessarily in the steps (Fig. 1), but rather in the inclusion of all of the stakeholders in the process of identifying problems and designing solutions, establishing an inclusive, optimistic, respectful, and collaborative mindset among participants. Inclusive collaboration is useful in many groups/ situations and intended to provide value to all stakeholders. However, its success as a collaborative tool is dependent on the level of trust of the involved stakeholders, the availability of resources, including time, the creation of a collaborative environment and other unique factors which can only be evaluated at the local level (Fig. 2).

4. Challenges and opportunities

Based on this model, the workshop zeroed in on three main challenges faced by miners: 1) a disconnect between the current laws and regulations aimed at ASGM and the on-the-ground realities of ASGM operations; 2) a lack of access to both technical and legal information; and 3) a need for improvements in the beneficiation and commercialization processes. The miners selected the disconnect between the current mining regulations and the actual realities of communities as their top challenge. They expressed that this disconnect creates a situation in which a standardized implementation of the law becomes almost impossible and creates barriers to national ASGM formalization. Miners felt that the laws should incorporate alternatives because of the fact that mining practices vary drastically across Peru, even within the same region. This problem included two parts: the divide between miners who are extracting the mineral and the owners of the mineral

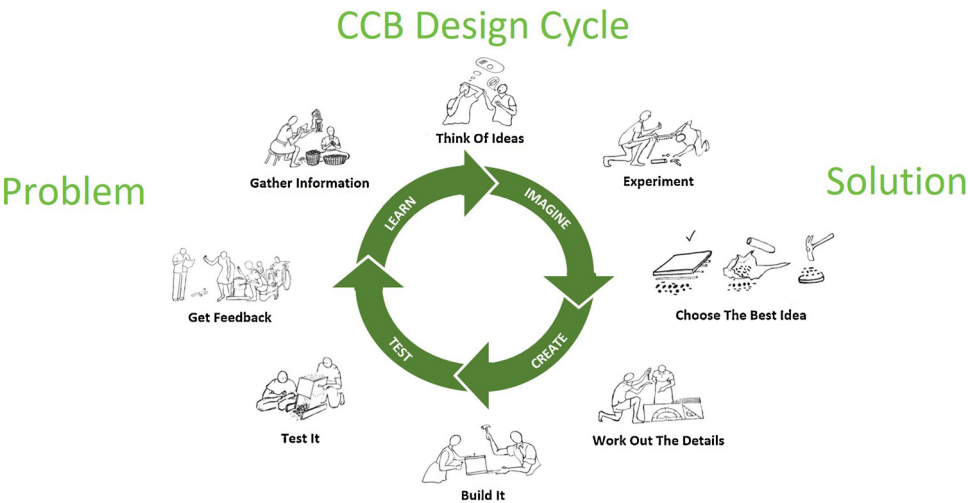


Fig. 1. Creative capacity building (CCB) framework for participatory design. The innovation is not in the steps, but rather in the inclusion of all of the stakeholders in the design process, establishing an inclusive, optimistic, respectful and collaborative mindset.

rights, and the overwhelming and cumbersome paperwork required to become formal that actually discourages miners from pursuing formalization. Miners described how often they were unable to negotiate with the mineral rights owners and that when negotiations did take place, they lacked transparency, creating, in the miners’ opinion, an unfair playing field and fostering illegal activity.

Pallaqueras, or women who work on the surface sorting ore for processing, presented a unique view of the main challenge. They viewed the links between laws and realities through the lens of recognition or acknowledgement as *pallaqueras*, something they do not currently have. “[Pallaqueras] are not recognized by the government and our work as *pallaqueras* is not appreciated or acknowledged. . . We only have informal agreements so that we can work.” They believe that recognition in the law will grant them and their families social benefits, as well as occupational safety resources. The *pallaqueras*’ main challenge within linking laws to realities was gaining recognition as key stakeholders in the ASGM community.

The second and third challenges that emerged, show that the miners are interested in improving working conditions, environmental stewardship, and occupational safety. Specifically, when miners spoke about improving working conditions, they referred to benefits (e.g. Social Security) and occupational safety. This was especially expressed on multiple occasions by the *pallaqueras*. Improving occupational safety also factored into miners’ reasons for wanting to learn about and share best practices, as well as demonstrating to the government that they are interested in improving their practices and progressing towards formalization. They emphasized their interest in environmental stewardship and stated that they want to leave a positive legacy for future

generations.

5. The pathway forward

The recommended pathway forward to resolve the main challenge was initially unclear. Some groups recommended broad actions such as changes to the laws but did not provide a clear pathway on how to start this process. Other groups stated that government officials needed to start coming to their communities rather than regulating from Lima and that there was a need for a national authority that unifies the miners. However, after much discussion, a main pathway forward emerged and included the need for a “united front” that would work to generate a new type of contract or agreement with government partners and address the realities of the constraints and opportunities presented to miners throughout Peru (not just in one region). Miners want to be able to articulate their needs and be part of the conversation and solution to ASGM formalization. In essence, miners want their voices to be heard. They also suggested a “single window” approach to formalization paperwork. In other words, they proposed a simple straightforward process that includes all areas (mining, environment, health, safety, employee rights) in one document.

The consensus position was that ASGM progress towards formalization hinges on the development of a forum that allows miners to articulate their needs and desires in collaboration with other key stakeholder groups, including government and large-scale mining companies. In addition to promoting ASGM needs and desires, such a forum would help address the lack of technical and legal information currently available to miners. Furthermore, it would need to be transparent and

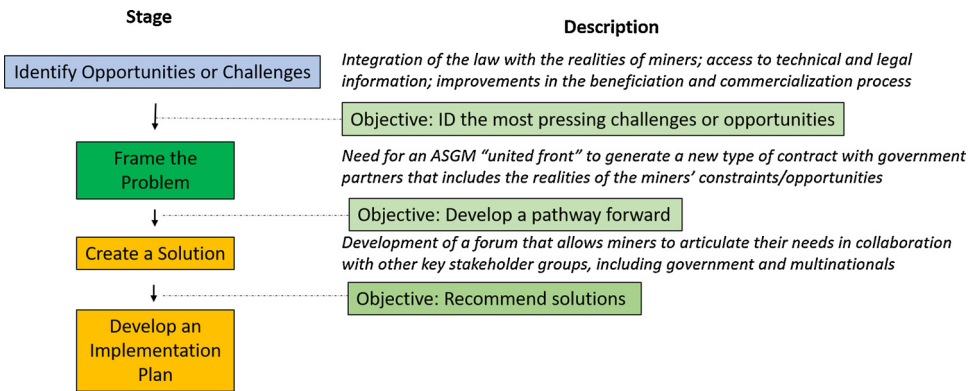


Fig. 2. Summary of design process from identifying opportunities and challenges, framing the problem, and developing a solution and implementation plan.

accepted by both regulators and operators. Legislative agencies across jurisdictions could rely upon the forum to assist with developing inclusive policies that allow artisanal and small-scale miners to achieve sustainable livelihoods, while reducing their environmental impacts and their vulnerability in shadow economies. Miners could rely upon the forum to articulate their needs, find common ground, and build capacity among their organizations. Next steps include the development of a forum-focused group with broad participation by all stakeholder groups, including miners in the ASGM sector, government and regulatory agencies, and large-scale mining companies.

The pallaqueras identified a pathway to link laws with their reality through recognition. The identified pathway to recognition involves the formation of an association and the establishment of collective ore processing facilities rather than at individual small plants. The pallaqueras want to find a physical space where this can be implemented. By doing this, they could seek recognition by the government to then secure programs such as social security and implement safety improvements.

5.1. Proposed actions

Recommendations that emerged from the workshop include a call for the funding and creation of a forum- focused group, homed in a neutral, possibly academic environment, with broad participation by all stakeholder groups. This group will be responsible for coordinating involvement by all stakeholders to maintain a transparent, fair, and widely-accepted process. The main purpose of this group would be to provide a unified voice to artisanal and small-scale miners with the goal of creating a national direction for policies and regulations. Initial funding would likely be from operators and environmental NGOs, with ongoing solicitation to industry associations, government, and other funders for longer-term support.

Although the miners continuously focused on the need for new agreements/laws/contracts, throughout the workshop, they ultimately agreed on the establishment of a national forum of artisanal and small-scale miners that would allow them to develop and broadcast a united stance on agreements/laws/contracts that impact their livelihood. The pallaqueras came to this conclusion much sooner in the discussion, as their interest in collaborating as a group to secure benefits for themselves and their families was a key motivator. Miners repeatedly expressed concern that the path forward for gaining regulatory approval is unclear and difficult to achieve but recognized their current “low” level of organization and the need and benefits of such an organization. Therefore, the establishment of a forum where miners’ voices can be heard, allowing them to propose new ideas to the government on behalf of all small-scale miners, is critical to the success of this initiative.

Recommended actions included the formation of a national level association with representatives from local regions. A governance agreement would outline the operation of the group. The association would need to be transparent and accepted by both regulators and miners, as well as government agencies across jurisdictions that could rely upon the association when drafting formalization and regulatory approaches. Large-scale mining (LSM) companies could rely upon this association when conceptualizing co-existence models between LSM and ASM in and around their government granted concessions. This could aid in driving business decisions and informing mine design and operations.

The association could potentially incorporate the following components, which are aligned with solutions that emerged from the Voces Mineras II participatory design workshop.

- a.) *Provide a voice:* As miners feel that their voices are never heard, they agreed that a national level forum would allow for integration of their ideas within the context of formalization. An association would allow for, as expressed by one miner, the “collection of the needs of all small miners to then construct suitable proposals for the

government.” As one miner stated while presenting on behalf of his group, “there is currently no dream for the small-scale miner; we need to create a national direction.”

- b.) *Initiate follow-on workshops* with diverse stakeholders such as those who participated in the *Voces Mineras II* workshop. Workshops would allow miners, NGOs, and government officials to discuss current regulations, share lessons learned, and craft proposals for the government.
- c.) *Contribute to advancing technology*, resulting in environmental improvements. In such an association, miners would be able to share technical knowledge and best practice examples, thereby building their capacity to take the lead in finding solutions to their own problems.
- d.) *Improve working conditions and benefits for miners* to provide a sustainable future for employees and families.
- e.) *Develop recommendations*, including agreed upon proposals that can be presented to the government in an effort to influence policies and regulations.
- f.) *Lobby to craft new arguments* including those to the government about the benefits of ASGM, as well as to promote their role in Peru’s economy to the people of Peru.
- g.) *Expand discussions and promote mining initiatives* through participation in conferences, newspapers etc.

6. Since the workshop

After the workshop, the miners who were in attendance created a social media group using a cross-platform messaging software, What’s App, allowing them to communicate broadly and disseminate information related to policies aimed at the ASGM sector. There are 41 members of the What’s App group, including miners, pallaqueras, and academics. The members of the group post daily, and the posts have been focused on the following topics: 1) The Minamata Convention on Mercury, which recently became law in Peru; 2) Las Bambas mine (Aurimac, southern highlands) and the conflict among industrial-scale mining activities and local, rural communities; 3) La Pampa zone (Madre de Dios, lowland Amazonia), from where gold miners were recently expelled due to their encroaching into conservation areas; and 4) A major law governing artisanal and small mining in Peru, which is currently being discussed in committee in the national Congress (videos and photos posted show several of the What’s App group participants present during such hearings). Follow up efforts continue to progress that encourage the expansion of discussions and collaborations beyond this forum. In addition to cross-platform messaging, efforts include the organization of a meeting focused on formalization, attended by hundreds of miners, depositions on congressional committees, presentations by miners and academics at international mining and environmental conferences and plans for future CCB efforts.

7. Conclusions

As seen from the broad participation and interest in the participatory design workshop, the consensus position, and recent informal efforts to coordinate, there is great desire and need for discussions surrounding ASGM, especially among the miners themselves. They want their voices to be heard, therefore requiring a forum to do so. A key to the success of such efforts is the immediate broadening of engagement beyond workshop participants and the solicitation of initial funding from industry, NGOs, and government for long-term support.

Pallaqueras were able to quickly narrow the scope of the broader challenge selected by the workshop participants (linking laws and realities) to the recognition of pallaqueras by the government. They see recognition by the Peruvian government as key to securing social benefits and therefore desire to work towards achieving this goal. The ASGM community in general also seeks recognition; however, the path to recognition, which involves formalization, remains unclear.

However, key to the success of any formalization effort is community level capacity building. Workshops, such as Voces Mineras II presented here, allow for the collective discussion of challenges faced by ASGM communities as well as defining pathways forward to solve such challenges. What was clear from the workshop was that efforts towards success hinge on the miners' ability to rally around one challenge and agree on pathway forward. During the two-day workshop many overarching concepts were discussed but working as a multi-stakeholder team to identify and agree on an actionable solution that could be pursued from inception to completion took time and patience. Ultimately, by providing a framework that allowed participants to identify their main challenge and participate in designing a solution to that challenge, they were able to develop a path forward. The hope is that the participatory methodology utilized in the Voces Mineras II workshop will effectively spur the mining communities to see the path through, making it easier for the next challenge, as well as providing all stakeholders a framework to work within for follow on initiatives.

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References

- Caballero Espejo, J., Messinger, M., Roman-Dañobeyta, F., Ascorra, C., Fernandez, L., Silman, M., 2018. Deforestation and forest degradation due to gold mining in the Peruvian Amazon: a 34-year perspective. *Remote Sens.* 10 (12), 1903.
- Cortés-McPherson, D., 2019. Expansion of small-scale gold mining in Madre de Dios: 'capital interests' and the emergence of a new elite of entrepreneurs in the Peruvian Amazon. *Extr. Ind. Soc.* 6 (2), 382–389.
- De Echave, 2016. La minería ilegal en Perú Entre la informalidad y el delito. Nueva Sociedad May-June 2016. Newspaper source. <https://nuso.org/articulo/la-mineria-ilegal-en-peru-entre-la-informalidad-y-el-delito/>.
- Diringer, S.E., Feingold, B.J., Ortiz, E.J., et al., 2015. River transport of mercury from artisanal and small-scale gold mining and risks for dietary mercury exposure in Madre de Dios, Peru. *Environ. Sci.: Processes Impacts* 17, 478–487.
- Gonzalez, D.J.X., Arain, A., Fernandez, L.E., 2019. Mercury exposure, risk factors, and perceptions among women of childbearing age in an artisanal gold mining region of the Peruvian Amazon. *Environ. Res.* 179, 108786.
- Hinton, J.J., Veiga, M.M., Veiga, A.T.C., 2003. Clean artisanal gold mining: a utopian approach? *J. Clean. Prod.* 11 (2), 99–115.
- Hussain, S., Sanders, E.B.N., Steinert, M., 2012. Participatory design with marginalized people in developing countries: challenges and opportunities experienced in a field study in Cambodia. *Int. J. Des.* 6 (2), 91–109.
- Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development (IGF), 2017. Global Trends in Artisanal and Small-scale Mining (ASM): A Review of Key Numbers and Issues. Winnipeg: IISD.
- Labonne, B., 2014. Who is afraid of artisanal and small-scale mining (ASM)? *Extr. Ind. Soc.* 1, 121–123.
- Martinez, G., McCord, S.A., Driscoll, C.T., Todorova, S., Wu, S., Araújo, J.F., Vega, C.M., Fernandez, L.E., 2018. Mercury contamination in riverine sediments and fish associated with artisanal and small-scale gold mining in Madre de Dios, Peru. *Int. J. Environ. Res. Public Health* 15, 1584.
- Martinez, G., Smith, N., 2019. Different Than the Rest: Formalization of Artisanal and Small-Scale Gold Mining in the Puno Region of Peru. In Preparation.
- Metcalfe, S.M., Veiga, M.M., 2012. Using street theatre to increase awareness of and reduce mercury pollution in the artisanal gold mining sector: a case from Zimbabwe. *J. Clean. Prod.* 37, 179–184. <https://doi.org/10.1016/j.jclepro.2012.07.004>.
- Mutemeri, N., Walker, J.Z., Coulson, N., Watson, I., 2016. Capacity building for self-regulation of the Artisanal and Small-Scale Mining (ASM) sector: a policy paradigm shift aligned with development outcomes and a pro-poor approach. *Extr. Ind. Soc.* 3 (3), 653–658.
- Orozco, Z.T., Viega, M.M., 2018. Locals' attitudes toward artisanal and large-scale mining—a case study of Tambogrande, Peru. *Extr. Ind. Soc.* 5 (2), 327–2334. <https://doi.org/10.1016/j.exis.2018.01.002>.
- Pimentel, M.S., Flórez, C.A., Restrepo, O.J., 2019. International interdisciplinary collaboration: artisanal and small scale gold mining and mercury contamination in Colombia. *Int. J. Interdiscip. Soc. Sci. Annu. Rev.* 3 (1), 2594–3405.
- Smith, N., Lucena, J., Smith, J., Restrepo, O.J., Delgado, G.A., 2018. Social dimension of the successful development of mining projects – a focus on artisanal and small-scale mining. *Int. J. Georesources Environ.* 4 (3), 99–104. <https://doi.org/10.15273/ijge.2018.03.017>.
- Smith, Nicole M., 2019. "Our gold is dirty, but we want to improve": challenges to addressing mercury use in artisanal and small-scale gold mining in Peru. *J. Clean. Prod.* 222, 646–654.
- Spiegel, S.J., Veiga, M.M., 2005. Building capacity in small-scale mining communities: health, ecosystem sustainability, and the global mercury project. *Ecohealth* 2, 361–369.
- Spiegel, S.J., 2019. Visual storytelling and socioenvironmental change: images, photographic encounters, and knowledge construction in resource frontiers. *Ann. Am. Assoc. Geogr.* 0 (0), 1–25.
- Stocklin-Weinberg, R., Veiga, M.M., Marshall, B.G., 2019. Training artisanal miners: a proposed framework with performance evaluation indicators. *Sci. Total Environ.* 660, 1533–1541.
- Quispe, J.L.S., 2013. 85% de mineros informales labora en áreas con dueños. La Republica 23 August 2013. Newspaper source. <https://larepublica.pe/archivo/733722-85-de-mineros-informales-labora-en-areas-con-duenos/>.
- Veiga, M.M., Angeloci, G., Niquen, W., Seccatore, J., 2015. Reducing mercury pollution by training Peruvian artisanal gold miners. *J. Clean. Prod.* 94 (1), 268–277.
- Wyatt, L., Ortiz, E.J., Feingold, B., Berky, A., Diringer, S., Morales, A.M., Jurado, E.R., Hsu-Kim, H., Pan, W., 2017. Spatial, temporal, and dietary variables associated with elevated mercury exposure in Peruvian riverine communities upstream and downstream of artisanal and small-scale gold mining. *Int. J. Environ. Res. Public Health* 14, 1582.