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Linking Ecological Economics and Political Ecology to Study Mining, Glaciers and Global Warming

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ABSTRACT
Ecological economics and political ecology offer complementary perspectives on economy–society–environment interactions. Although both refer to values and perceptions, ecological economics focuses on what provides benefits and how values can be elicited, and political ecology scrutinizes the socio-political setting within which preferences are revealed. Linking the two areas of study makes it possible to depict socially constructed values that are affected by different discourses and power inequalities, as well as by the stakeholders' geographical distance from the issue concerned. Mining activity is a special case, because the selection of potential sites is restricted by the natural distribution of resources, bringing them to the attention of different stakeholders. Mining interferes with ecosystem structure and function, making the trade-offs between different uses of the environment explicit and demonstrating how difficult it is to protect ecosystem services, especially in some political settings. Two case studies (Kumtor in Kyrgyzstan and Pascua-Lama in Chile–Argentina) illustrate how gold mining interferes with glaciers and how this may be affected by changing perceptions of global warming. In the case of Kumtor, at least 39 million m^3 of glacier ice were removed by the end of 2011, but this intervention and the subsequent consequences escaped public attention. Meanwhile, the plans to remove 0.8 million m^3 of ice, in the case of Pascua-Lama, led to widespread protests in which local communities were joined by overseas pressure groups and other stakeholders. The factors that led to the disparity of interest and opposition in the two case studies reflect larger market, government and social empowerment failures in Kyrgyzstan.

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Introduction

Increased awareness of the consequences of global warming leads to new societal perceptions of the value of ecosystem services, such as those related to glaciers. In the public debate in developed countries, glaciers have become 'an endangered species' (Carey, 2007), which is reinforced by the use of their images as an illustration of the consequences of global warming (see, e.g., Gore, 2006). Thus, demand for ecosystem services related to glaciers increases with increased awareness of the glaciers' scarcity and importance.

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Apart from global warming, glaciers are affected by occasional economic undertakings, such as large-scale low-grade open-pit mining. Few cases have been recorded where mining interfered with glaciers, but more are likely to occur when stimulated by economic incentives to exploit deposits that were previously unprofitable. Although changes in a glacier's area and volume introduced by mining are minor compared with those caused by global warming, society can more easily counteract them. Two gold mines (Kumtor in Kyrgyzstan and Pascua-Lama in Chile–Argentina) provide useful examples. When the construction of Kumtor mine started in the early 1990s, not many people expressed concern about the fact that some glaciers would be affected. Ten years later, when the Pascua-Lama was proposed, this issue attracted much more attention and led to the legal protection of endangered glaciers on the site and to the development of the glacier protection policies in Chile and Argentina. Thus, the underlying hypothesis is that the motives to protect glaciers from gold mining differ across time and space, and depend on the economic and socio-political circumstances of the countries where glaciers are located.

This article analyses and compares two case studies. Adopting a political ecology perspective, it focuses on stakeholders and their discourses (including multinational corporations, NGOs, local populations, governments, international advisers, and researchers who study glaciers). The case of Pascua-Lama is widely known because of the interest it has attracted worldwide, and it has also been discussed with reference to political ecology (cf. Franks, 2007; Urkidi, 2010). Meanwhile, Kumtor has remained hidden from the world's interest, principally because of the political situation in the country. This article is based on a review of the literature, complemented with direct consultations with stakeholders in the case of Kumtor (Kumtor Operating Company, as well as local researchers and local NGOs, most of which have adopted a rather cooperative approach and are not necessarily opposing the mine, at least not because of its interference with glaciers). The ecological economics perspective focuses on ecosystem services and their value. Although stakeholders' preferences have not been quantified, it is assumed that their acceptance or opposition towards gold mining projects interfering with glaciers reflects these preferences, at least to some extent. Clearly, these preferences are dynamic and change in response to further stimuli, such as other activities of mining companies (e.g. sponsoring campaigns).

The following section provides a theoretical background for this paper, followed by a review of services provided by glaciers, the different types of value, and how these values might affect the political motives to protect glaciers. The data section inspects how mining interferes with glaciers, based on the overviews of Kumtor and Pascua-Lama gold mines. Then, the circumstances that led to different perceptions of glaciers in the two case studies are discussed. The last section concludes with some remarks on how the revealed preferences towards glaciers could be used to preserve them for the benefit of glaciated regions.

Theoretical Background

This study contributes to building links between ecological economics and political ecology (cf. M'Gonigle, 1999; Martínez-Alier, 2002; Sneddon *et al.*, 2006; Gerber *et al.*, 2009; Martínez-Alier *et al.*, 2010). Ecological economics and political ecology combine the social and material approaches to environmental governance and take into account the different perspectives on the value of ecosystem services (Martínez-Alier *et al.*, 2010). Indeed, values are not 'neutral' but socially constructed and affected by different discourses and power inequalities (M'Gonigle, 1999). The different values are reflected in the discourses of relevant stakeholders (Derman and Ferguson, 2003). In many cases, principally in the case of use values, the value of ecosystem services decreases with distance from the ecosystem that provides those services (see, e.g., Sutherland and Walsh, 1985). However, in the case of non-use values, information availability is the main determinant. Thus, the value may be high for geographically distant stakeholders because of their preferences, especially when those living within a close proximity to the source of an ecosystem service manage to raise the distant stakeholders' interest.

Political ecology studies situations where different stakeholders reveal different paradigms (and value perspectives) and where they have unequal powers to shape a situation in question. It focuses on the roles of various actors in decisions referring to environmental issues, often with reference to actors acting at different scales (Bryant, 1997; Bryant and Bailey, 1997). Although frequently political ecologists first focus on a situation at the local level and then broaden their scope of analysis, sometimes it is useful to start from the global perspective and then move to the local

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level (Paulson and Gezon, 2005). This is important with reference to global issues, such as global warming, and their impacts on local contexts, as illustrated by the case studies considered in this article.

Political ecologists indicate that 'powerful states and businesses can determine the spatial distribution of hazardous activities, and by extension, which groups in society are most exposed to the costs of such activities' (Bryant, 1997, p. 11). Mining activity is a special case because the selection of potential sites is restricted by natural distribution of resources. Thus, companies have fewer choices and are more likely to exert their power to establish their activity in a given location. However, for the same reasons, it is also easier to focus the attention of wider groups of society on these spots, providing a counterbalance of power.

Those who have studied mining within the context of political ecology have focused on problems such as the exploitation of indigenous populations and land rights (Moody, 1992; Watts, 2001; Hitch, 2006; Bury, 2008; Urkidi, 2010), access to water (Bebbington *et al.*, 2008), access to various resources (Bury, 2008) and conflicts between mining and forestry (Bryant and Bailey, 1997). With the exception of Urkidi (2010), so far these issues have not been discussed with reference to glaciers. Indeed, impacts on glaciers have also been omitted from most studies on 'sustainable mining' (e.g. IIED and WBCSD, 2002; Mudd, 2007) and on the environmental impacts of mining (e.g. Ripley *et al.*, 1996). This situation started to change because of the widespread attention that has been drawn to the Pascua-Lama gold mining project, even though other mines had interfered with glaciers on a larger scale before, the best example of which is Kumtor gold mine.

While in the abovementioned studies conflicts were often presented from the perspective of stakes and discourses of different stakeholders and the forms of their activism, here the focus is on a more general political and social setting that makes possible the expression of the former. Even though in some situations threats are more real and more substantive than in the case of others, a conflict may not emerge because

- there are no stakeholders directly and immediately affected by mining operations who would raise concerns,
- there is not enough information on the potential threats of the mine for other stakeholders, farther away, and
- the political setting makes expressing the concerns more difficult.

Indeed, because of these factors only one of the case studies analysed here represents a conflict situation, while the other has not evolved into conflict yet, precisely because the specific political setting made conflict escalation very unlikely.

Besides, much political ecology literature tends 'to essentialize actors such as the state, NGOs, or local community organizations and treat them as monolithic entities', while in reality there may be important differences within each group (Bury, 2008). Indeed, in both case studies local stakeholders represented diverse viewpoints on mining and glaciers, but some of their voices were not heard, which again links to the general socio-political setting. Bebbington *et al.* (2008, p. 2902) noted that the stakes of local stakeholders 'cannot be understood independently of the scaled economic, political, and social relations in which they are embedded'. Similarly, 'counter-coalitions' in which local stakeholders would be joined by foreign supporters of their interests, and which could withstand the coalitions of larger actors (Bryant, 1997), are not always possible, again because of the general socio-political setting.

To summarize, frequently political ecology focuses on power relations and studies conflict and activism. This study focuses on why a conflict is more likely to emerge in some circumstances than in others. Two different case studies represent the different circumstances that may lead to the emergence of conflict or prevent a conflict from developing. They reveal that democracy, openness to the world and empowerment of local stakeholders are the most important factors that can contribute to social control of mining projects.

Services Provided by Glaciers

Reviewing the services provided by glaciers (Table 1) reveals various use and non-use values that might be assigned to the stocks of glaciers and the flows of glacier runoff, and the character of the related economic benefits. These benefits can have a direct or indirect character for different stakeholders and can be valued with market or non-market valuation techniques respectively. Eventually, whether expressed, calculated or not, these values translate into political motives to protect glaciers.

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Character of economic value	Service
Use value	Source of fresh water
	Source of ice (e.g. for food and medicine preservation)
	Contributing to the regulation of climate
	Regulating stream temperatures
	Tourism
	Information about the history of the Earth and about the behaviour of climate
	Preservation of specimens of past life forms
Non-use value	Existence value
	Bequest value
	Altruistic value
Negative value	Creating a barrier to the development of a given project
	Natural hazards

Table 1. Glaciers' services and their valuation

Glaciers are probably best known for being the source of fresh water, which is particularly important in arid regions. Indeed, glaciers and ice-rich permafrost constitute the primary permanent store of water in both regions referred to in the case studies below (Bolch and Marchenko, 2006; Azócar and Brenning, 2010). They accumulate and store water that can potentially be used in the future, thus also contributing to the regulation of climate – reducing temperature and increasing precipitations. To emphasize this hydrological perspective, mountains are sometimes referred to as the 'water towers' of the world (see, e.g., Messerli *et al.*, 2004). This function is crucial for agriculture, energy generation and other economic sectors dependent on water, and indeed also for human survival. Furthermore, glaciers moderate variations in stream temperatures, which have implications for fish populations and fishing (Pederson *et al.*, 2006).

Tourism opportunities offered by glaciers, such as skiing, ice-climbing and trekking, constitute another important example of a use value. These values might be estimated by studying the economic benefits achieved by regions with glaciers or surveying the preferences of individual tourists using glaciers. The most unusual (the largest, the most scenic) and the most accessible glaciers would score the highest values.[1]

Another example of a use value, though more difficult to estimate, is a glacier's ability to provide information about the history of the Earth and about the behaviour of climate. Currently, glaciers are frequently used as an indicator of global warming. They also offer a potential study material for various sediments reflecting the atmospheric conditions in the past, and sometimes uncover spectacular specimens of past life forms (including now extinct animals and earlier people).[2] In the latter case, market values might emerge if uncovered specimens were shown in museums or other exhibitions, thus generating economic benefits in terms of ticket sales. Another example of a use value provided by glaciers is that of ice collected from glaciers and used for preserving food or medicine (Rhoades, 2007).

Existence, bequest and altruistic values represent the non-use values of glaciers. For people concerned with environmental issues, it is important to know that glaciers exist, even if most of them would not personally use a glacier (cf. Carey, 2007). Also, some modern myths and legends, based on stories of heroism and tragedy in mountain climbing, focus on glaciers. With growing awareness of global warming resulting in glacial melting, these values tend to increase. The remaining glaciers are likely to be worth more in the future, and people are interested in leaving this 'treasure' for future generations or for other, contemporary people depending on them as a source of water. Additionally, for some indigenous people, peaks covered by glaciers are revered as religious symbols (Rhoades, 2007; Vergara *et al.*, 2007). Such a spiritual value is also perceived by some people of modern society (Ehrlich, 2004; Orlove *et al.*, 2008). These values might be revealed with non-market techniques such as contingent valuation.

[1]The shaping of the Earth's surface by glaciers can also contribute to making some regions more touristically attractive. However, this function operates on time scales too large to be incorporated in most valuation studies and it mostly refers to the past rather than current activity of glaciers.
[2]To a small extent, glaciers also provide habitat for *living* life forms. For example, some debris-covered glaciers have vegetation growing on their debris (Fickert *et al.*, 2007). However, the related economic value seems negligible.

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Alternatively, from the perspective of an individual company rather than the whole society, glaciers may create a barrier to the development of a given project. In this way, they would prevent the company from realizing a value associated with an alternative land use. For example, describing the times of the early US settlement in Alaska, Martin (1913) classified glaciers, among other things, as barriers to communication, transportation (railroads, roads, waterways), plant and animal life, and hydropower, and as forces destroying ports and settlements.[3] In particular, this view has been expressed with regard to mining, which also dates back to the early times of mining expansion to areas previously difficult to access (Martin, 1913, p. 812; Fisher and Jones, 1971; Eyles and Rogerson, 1977a, 1977b; Clarke and Holdsworth, 2002, p. J296; Citterio *et al.*, 2009).

The other example of a negative value refers to glacier-related natural hazards, such as glacial lake outburst floods, glacier surges, ice and other avalanches, or land destabilization related to permafrost thawing. These hazards are further reinforced by global warming (Carey, 2010). They can affect up to hundreds of kilometres of area below a glacier, and the related damages and mitigation costs are estimated at several hundred million EUR as a long-term annual average global sum (Kääb *et al.*, 2005a, 2005b). Indeed, land instability and the risk of a glacial lake outburst constitute significant problems in the case of Kumtor mine (Bruce *et al.*, 2008; Janský *et al.*, 2009, 2010). The negative value of a glacier might be revealed as losses directly incurred as a result of glacier activity.

Benefits that people derive from glaciers (or, in the case of negative values, from glaciers' loss) are affected by decisions that people make. Reducing the stocks of glaciers will limit future availability of water (flow) and lead to changing local climates. The vulnerability of people dependent on glacier water to climate change may bring about economic costs, such as increased risk of conflicts, increased migration and food insecurity (Messerli *et al.*, 2004). Furthermore, water originating from glacier runoff in some countries (e.g. Kyrgyzstan and Tajikistan) is then used in neighbouring countries, for example being sold to them in the form of hydropower. Glaciers' melting will undermine market benefits currently emerging from this exchange. Vergara *et al.* (2007) calculated the economic consequences of glacier retreat in Peru by looking at the costs of replacing hydropower with alternative energy sources and the costs of rationing energy in the transition period. Conversely, glaciers' melting with global warming can also lead to increased mining opportunities in places previously covered with glaciers, as the example of the current mining boom in Greenland demonstrates (*Mining Journal*, 2008).

Eventually, the value of glaciers and the preferences towards glaciers are affected by uncertainty about their future dimensions and ability to provide their services. They also suffer from widespread ignorance regarding glaciers' functions, as well as their fragility and vulnerability. Lack of valuation, inadequate valuation or inadequate expression of preferences may increase the risk of further degradation with the introduction of large-scale environmentally intrusive projects, including gold mining.

Data: Mining and Glaciers

With technological progress, and growing demand and prices, new mining projects open in areas where exploitation has not been feasible previously. This also includes sites covered with glaciers, which become more accessible with global warming.

Mining that might potentially affect valuable natural sites has always raised controversy, and areas with glaciers have been no exception, as demonstrated by the long-running debates on mining in the then Glacier Peak Wilderness Area (Washington State) or in the then Glacier Bay National Monument (Alaska) (see, e.g., Sperry, 1967; Carter, 1968; Liska *et al.*, 1968). The extent of controversy depended on information availability regarding mining projects potentially interfering with glaciers or destroying areas otherwise valuable because of glaciers.

The two case studies analysed in this article are not exceptional, in that there are other mining projects in the world that affect glaciers. Mining under glaciers happens, both in the mountains (see, e.g., Clarke and Holdsworth, 2002; Brenning, 2008) and in polar regions (see, e.g., Melvold *et al.*, 2003; Christiansen *et al.*, 2005). However, except for the examples referred to by Brenning (2008) and Brenning and Azócar (2010), the above refer to

[3]An even earlier example refers to the early Norse settlements in Greenland and their failed attempts to colonize North America around AD 1000 (Diamond, 1997, pp. 371–372).

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Figure 1. Location of Pascua-Lama and Kumtor gold mines and the surrounding glaciers and rivers (maps by Marta Plachta)

underground mining, under the earth covered by glaciers, which affects glaciers less than the open pit mining adopted in both Kumtor and Pascua-Lama.

The following case studies, one of an operating mine (Kumtor) and the other of a mine under construction (Pascua-Lama), originate from high mountain areas covered with glaciers and surrounded by arid regions (Figure 1).[4] They provide an illustration of how mining can interfere with glaciers and the different attitudes towards this interference that may emerge, reflecting the perceived value of glaciers (as summarized in Table 2). The two subsections below present general information on both projects and their impacts on glaciers. The second case study includes information on the broader discussions that accompanied the formal approval of the mine, which was not relevant for the first case study and thus has been omitted from its description.

Kumtor

In 1992, the government of Kyrgyzstan signed an agreement with Cameco, a uranium company, creating Kumtor Gold Company. Subsequent discussions led to many changes in the feasibility study originally presented by Cameco (Sarygulov, 2000, pp. 168–174). However, thanks to political support, the planning process was simplified and an officially required EIA that did not mention any significant environmental impact was only submitted just before production started in May 1997, not allowing for any proper public consultations. Since then, until the end of 2009, the mine has produced 7.2 million ounces of gold (Centerra, 2010, p. 4). Constant exploration and increasing gold prices (through reducing the cut-off grade) have contributed to significantly enlarging the mine's reserves and the number of pits. The mine is currently planned to operate in its current form until 2021 and later underground mining will continue.

The mine is located in the Tien Shan mountains, in the east of Kyrgyzstan (41°52'N, 78°12'E). It lies in the zone of active glaciers and permafrost reaching 100–250 metres of depth (Torgoev and Aleshin, 2001; Bruce *et al.*, 2008). Two peculiarities of the Kumtor mine refer to glaciers: removing glaciers and storing waste on those that remain.

1. As the pit's outline included some area covered with glaciers, these had to be removed (Figure 2). In fact, glacier ice needed to be removed beyond the pit's outline, to protect the mine from glacier flow. When construction started, the maximum glacier depth over the future mine was 40 m. By the end of 2007, in addition to 59.5 million tonnes of ore

[4]Detailed maps showing the impacts of both mines on glaciers can be found in Bruce *et al.* (2008) and Barrick (2011).

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	Kumtor	Pascua-Lama
Construction started	1994	2009
Gold production started	1997	2013 (planned)
Predicted operation years	24+	25+
Proven and probable gold reserves (million ounces; 31 December 2009)	5.5, plus 7.2 extracted so far	17.8
Elevation (metres above sea level)	3600–4400	3800–5200
Forms of interference with glaciers	Removing glaciers (5.9 million m^3 until 2007, 11 million m^3 in 2010, 22 million m^3 in 2011), storing waste on glaciers and redirecting their flow	Initial plans assumed removing glaciers (0.8 million m^3); revised plans assume no interference with glaciers

Table 2. General information on Kumtor and Pascua-Lama

and 639 million tonnes of waste rock, 5.9 million m^3 of glacier ice were also extracted (Bruce *et al.*, 2008, p. 37). More recently, when pit outline was enlarged and glacier flow accelerated, the need to remove ice increased, significantly exceeding the volume of ice excavated so far. In 2010 around 11 million m^3 and in 2011 around 22 million m^3 of glacier ice were extracted from the central pit only (KOC, 2011, 2012). Glaciers are broken with traditional explosions.

2. Since the beginning of mine construction, glaciers were charged with waste rock, both as a means of disposing of waste rock as close to the pit as possible in order to reduce transportation costs, and as a way of directing glaciers away from the pit (and creating a barrier separating the mining area from active glacier). The proximity of waste rock dumps helped to keep operating costs low until 2005 (Sarygulov, 2000, p. 175; Thalenhorst and Farquharson, 2004, p. 2; Bruce *et al.*, 2008, p. 115). This glacier 'engineering' has helped effectively to protect the mine, and it is planned to continue (Bruce *et al.*, 2008, p. 74). Nevertheless, glacier-related risks persist, the most important of which is the instability of pit walls. The most significant pit wall failures occurred in 2002 and 2006, resulting in one fatality, substantial decreases in production and increased costs. As water seeping from the overlying glacier reduces the scope of permafrost, and thus contributes to this risk, more ice is scheduled to be removed from the overlying glacier and melting water is scheduled to be directed away from the pit (Bruce *et al.*, 2008, pp. 5–6).

Other potential problems related to the activity of Kumtor mine refer to magnifying the risks related to an adjacent glacial lake's probable outburst, increased melting of surrounding glaciers and acid rock drainage.

- The mine is located in the vicinity of the sources of the Naryn (which later joins with the Kara-Darya to form the Syr-Darya). In the case of Kumtor, the risk of polluting the Syr-Darya is aggravated by the possibility of an outburst of a large glacial lake (Petrov Lake) adjacent to the mine, above the tailings dump. This risk is aggravated with global warming increasing the surface and volume of the lake and decreasing the stability of its dam, constructed partly of ice; and it will persist after the mine's decommissioning. As recently discovered, this risk is further increased because of the intense calving of Petrov Glacier, which generates water surface waves that increase the risk of the lake dam failure (Engel *et al.*, 2012). Indeed, because of the above dynamics and the large volume of water, Petrov Lake is considered one of the most dangerous alpine lakes in Kyrgyzstan and, possibly, in the whole of Central Asia (Janský *et al.*, 2009, 2010). The stability of the tailings dump's dam is uncertain, too. It has been sliding slowly due to the degradation of permafrost below and many attempts have been made and are still being made to secure the dump itself.
- Increased melting might result from the estimated 3–4 tonnes of dust, emitted daily at the mine site (Torgoev and Aleshin, 2001, pp. 51–52), as well as from transportation and exploration (Bogdetsky, 2001, p. 61). According to Dikikh (2001), this might affect glaciers in the radius of 60–100 km. However, the albedo-decreasing effect of dust might be neutralized by the relatively high precipitation in this area (Aizen *et al.*, 1995, 1997).
- Acid rock drainage, an environmental problem caused by many gold mines in the world, could possibly be exacerbated at Kumtor, due to the storing of waste rock on glaciers and consequent pollution of surface water

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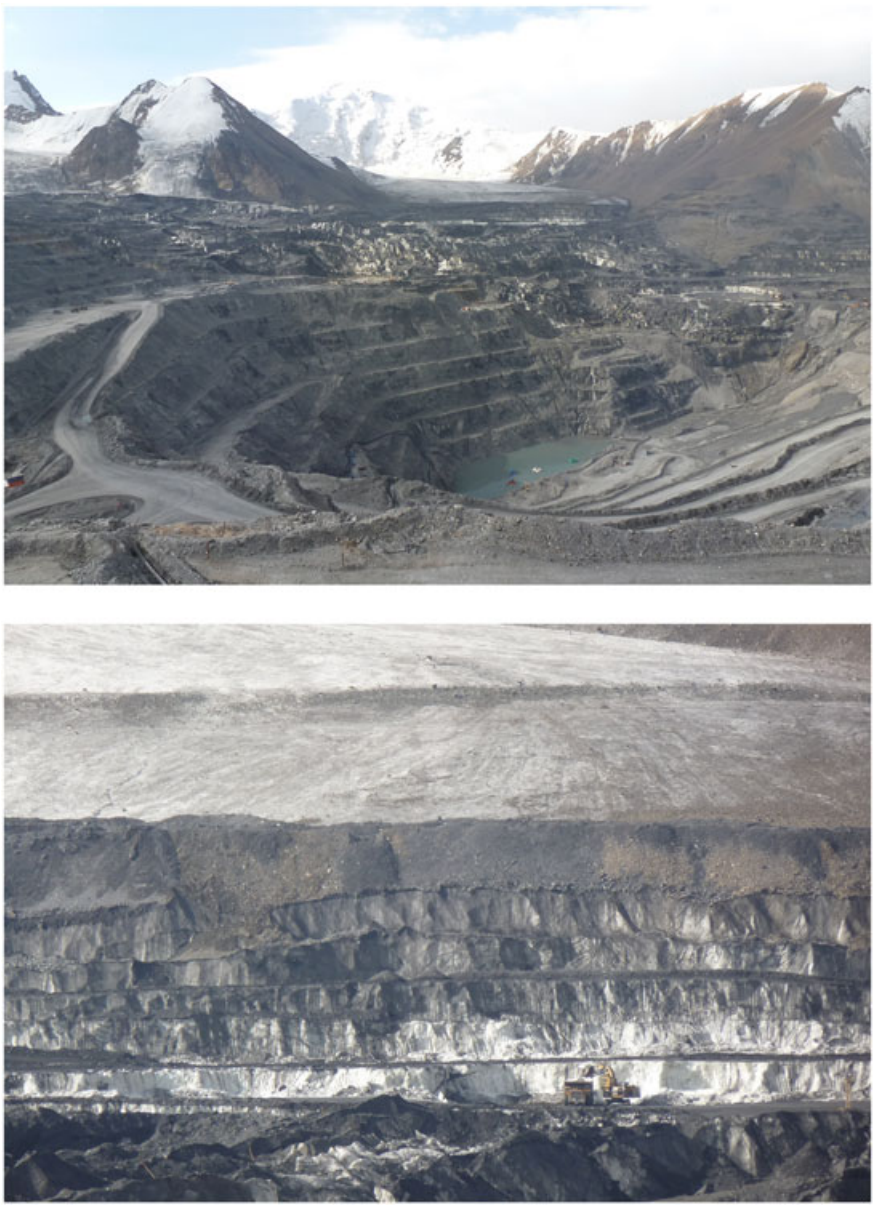

Figure 2. Glacier ice is being excavated at Kumtor mine in Kyrgyzstan (photos by Zbynek Engel)

and ground water (Torgoev and Aleshin, 2001, p. 76). However, this is refuted in the mine's technical reports (e.g. Thalenhorst and Farquharson, 2004, p. 65; Bruce *et al.*, 2008, p. 115).

The three active glaciers directly affected by the mine are Lysyi, Davidov and Sary-Tor. They form part of the Ak-shirak range, which is estimated to have lost 8.6% (35.15 km^2) of its glaciers' area between 1977 and 2003 (Aizen *et al.*, 2006). According to other estimates, 23% of Ak-shirak glaciers' area was lost between 1977 and 2001 (Khromova *et al.*, 2003), but the reliability of these results has been questioned (Khalsa *et al.*, 2004; Aizen *et al.*, 2006). Kumtor mine's contribution to this loss was estimated at around 0.7 km^2 of ice (Khromova *et al.*, 2003), about 2–4% of the entire area loss in the Ak-shirak range. In terms of volume of ice destroyed, the mine's total contribution is 0.09–0.16% (according to Aizen *et al.* (2006), the volume of Ak-shirak glaciers diminished by 6.147 km^3 between 1977 and 2000). If this contribution seems small, it is because Ak-shirak is the second largest glacierized massif in the Tien Shan and it is compared to a period of glacier change longer than that of the mine's operation.

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Pascua-Lama

Pascua-Lama mine is located in the Andes, on the Chile–Argentina border (29°19'S, 70°01'W), with glaciers under consideration on the Chilean side only. In this case, significantly less ice was supposed to be removed (830 000 m^3, according to 2005 plans), and these glaciers were already in the process of disappearing (Rabatel *et al.*, 2008). Nevertheless, public attention was drawn to the issue and there was large pressure on the mining company (Barrick) to change its plans so as not to affect the glaciers. The conflict started with local protests, later joined by national and international pressure groups in what can be called a glocal movement against the mine (Urkidi, 2010). Although the protests have not stopped the mine, they politicized the issue of mining and glaciers.

Initially, Barrick intended to move the smaller glaciers covering part of the goldfield away from the site and store the ice nearby, within the same watershed. This was authorized by the 2001 approval of the EIA (submitted in 2000). Meanwhile, the volume of ice to be transplanted grew from 300 000–500 000 m^3 to 830 000 m^3, along with the opposition to such an operation from local stakeholders, the international community and Chilean government. As the conflict between local communities and the mining company intensified, growing attention has been paid to the potential threats posed by the mine: to agriculture, the environment and people's health. Removing glaciers symbolized all of these problems. Continuing protests against Pascua-Lama led to the discussion in Chilean parliament of a glacier protection law, instead of which only a policy was adopted in 2009.[5] In her presidential campaign in 2005, Michelle Bachelet declared that she would not allow the removal or destruction of glaciers in Chile, which she repeated after taking office in 2006.

In the final decision of February 2006, Chilean environmental authorities required that Barrick does not remove, relocate, destroy or otherwise physically intervene with glaciers; and protects them and monitors their state (Comisión Regional del Medio Ambiente, Región de Atacama (COREMA), 2006). Clearly, it is also not allowed to store waste on glaciers or change their albedo in any way. In response, the company redrew the pit's borders, barring access to approximately 7% of gold deposit (from 18.3 to 17 million ounces) and precluding future expansion to the south of the planned pit, and pledged to map and photograph glaciers, study their solar reflectivity and melt water volumes and properties, and monitor microclimate, energy and mass balances (Environmental Resources Management (ERM), 2006, pp. 21, 24).

The glaciers at Pascua-Lama were described by Barrick as 'small patches of remnant glaciers that are steadily melting in recent climates and more active glaciers 1 to 2 km away from the proposed mine site' (Environmental Resources Management (ERM), 2006, p. 4). The 'small patches' are called Toro 1, Toro 2 and Esperanza and cover about 20 hectares of the gold field (with their total area of about 34 hectares). According to the company, 'these bodies of ice have been classified by glaciologists as "glacierets" or "ice reservoirs" rather than traditional glaciers, and consequently their contribution to the water resource of the Huasco Valley is considered to be insignificant' (Barrick, 2011).

At least partly because of mining exploration and other preparatory work in this area, glaciers already diminished by 9–79% of their volume from 1955 to 2007, in particular since 1996. Although this must have been influenced by climate change, other glaciers in the area have diminished less significantly. With or without the mine, the three small glaciers are likely to melt within 15–75 years (Rabatel *et al.*, 2008), because of global warming. Barrick declared that it would not mine the area currently covered by glaciers even when they are gone (Harris, 2007). However, this constitutes an example of the public relations activity of the company, building on the revealed societal preferences towards glaciers.

Results and Discussion

Combining ecological economics and political ecology allows us to look at preferences towards glaciers revealed by different stakeholders. These preferences are revealed in the roles that stakeholders played in both case studies and reflect the values that they attribute to glaciers.

Clearly, both companies perceive glaciers as obstacles to the development of their mining projects. They used their bargaining power to reduce opposition to their mining projects, which was particularly successful in the case of Kumtor and more difficult in the case of Pascua-Lama.

[5]In Argentina, a glacier protection law was enacted in 2010.

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In the case of Kumtor, the company operating the mine was initially half-owned by the state, which made protesting against it much more difficult. A few protests focused on other issues (such as cyanide spill) and not on interference with glaciers. In most national debates in Kyrgyzstan, Kumtor is presented as an engine for regional and even national economic growth and there is little discussion on the potential side effects of the mine's operations. Moreover, it is seen as operating in a remote, uninhabited area and thus unable to affect the population (except for the evident risks of accidents related to transportation of chemicals to the mine).

In the case of Pascua-Lama, an alternative viewpoint was expressed by local communities and then by national and international pressure groups, opposing the mine because of its planned interference with glaciers. Although glacier damage was one of many problems that spurred local protests (cf. Urkidi, 2010), it was relatively easy to focus international attention on this issue, because of the non-use values and symbolism of glaciers. The preferences of local stakeholders referred to use values of glaciers (water availability for downstream communities), while those of overseas actors reflected the existence, bequest and altruistic values of glaciers (as most of them would not have gone to the location to enjoy the scenery, nor would directly benefit from the water that those glaciers provide). Local protesters were forming coalitions with pressure groups from developed countries involved in other conflicts over mining and water in Latin America, thus upscaling the conflict to national and then international levels (cf. Bebbington *et al.*, 2008, 2010). To some extent, it could even be argued that, as glaciers are prime symbols for the (real and demonstrated) threat of global change in a wider sense, it is rather a more general political and societal protest that focuses on the Pascua-Lama project. This is independent of the use or non-use values of the stocks of glacier ice and the flows of glacier runoff, and independent of the techniques that could be used to assess these values.

However, neither local nor overseas stakeholders were unanimous, and their attitudes probably depended on the perception of economic opportunities offered by the mine – more economically powerful local stakeholders reached an agreement with Barrick as early as 2005. The company used its economic power to gain support from other stakeholders (supporting local projects, running a public relations campaign and establishing relationships with local and national politicians), trying to present protesters as extremists (Urkidi, 2010). Barrick was also supported by the Canadian government.

From the point of view of the value of glaciers, the 2006 verdict of Chilean authorities obliging the company not to interfere with glaciers softened the protests. The company appeals to the preferences of those who care for glaciers by reiterating that it does not affect glaciers, conforming to the requirements of Chilean authorities. Meanwhile, Barrick's lobbying activities aimed at weakening glacier protection laws in Chile and Argentina remain largely unnoticed by the general public.

The fact that preferences regarding glaciers were revealed in the case of Pascua-Lama, and not in the case of Kumtor, suggests that they depend on a number of circumstances that vary from country to country, and from time to time (Table 3). This list expands the determinants of mining and anti-mining activity considered by Bebbington *et al.* (2008) and includes the dependence of a country on mining, the general economic situation and the size and lobbying capacity of a mining company. The differences between Chile and Kyrgyzstan refer to political traditions, political rights, quality of institutions, the character of public decision making, opportunities for NGO involvement and the economic situation (including the significance of the project for the national economy). Finally, awareness and interest in the area of global warming increased significantly between the early 1990s and the early 2000s, and so did access to the internet, providing information from around the world and an opportunity to organize social movements. This is also confirmed by the fact that other mining projects affecting glaciers in Chile in the early 1990s did not raise interest similar to that in Pascua-Lama (Brenning, 2008).

With better access to information on Pascua-Lama, and exposed to the emotionally laden campaign, the preferences of overseas stakeholders were inflated by ethical considerations (cf. Gowdy, 1997, p. 31). According to Barrick's information, the disputed glaciers contribute an insignificant amount of water, less than 0.5% of the total watershed ('less than 2 litres per second during maximum seasonal melting'; Environmental Resources Management (ERM), 2006, p. 21; Fields, 2006, p. A538). Meanwhile, for the global community, it counts that glaciers exist and the information that glaciers were to be removed to facilitate mining in Chile provided a tangible symbol of an additional threat to glaciers, which were already exposed to another threat – global warming. The existence value of glaciers is increasing along with rising awareness of the consequences of global warming, which conforms to the traditional economic perception of prices rising in response to supply being limited.

Relatively few glaciers are mined and thus there are few opportunities for similar cases to occur in the future. The isolation of the case of Pascua-Lama, as compared here with the other mining project, which interferes with glaciers

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	Kyrgyzstan	Chile
Political tradition	Top-down authoritarian approach, partly inherited from the USSR.	Liberal approach.
Political rights, civil liberties	Since the beginning of the 1990s, Kyrgyzstan has been classified as either non-free or only partly free, with particularly low scores since 1998 (Freedom House, 2011). Opportunities for spontaneous protests against the project were very limited (lack of civil society, strong inheritances from the USSR).	At the same time, Chile has been classified as a free country with regard to political rights and civil liberties, and since 2003 it has achieved the maximum scores in both categories (Freedom House, 2011). This translates into freedom of speech and opportunities to protest for the local communities to be affected by the mine's operations.
Quality of institutions	Poor quality of institutions in Kyrgyzstan (see, e.g., Dabrowski, 2000; Cokgezen, 2004), with neglect of the basic rules of law and high corruption (Corruption Perceptions Index scored 1.8–2.3 on a 1–10 scale (10 representing no corruption) for 1999–2010; Transparency International, 2010).	With a longer tradition of democracy, Chile is often praised for the quality of its institutions, also reflected in low corruption (Corruption Perceptions Index scored 6.9–7.5 on a 1–10 scale (10 representing no corruption) for 1995–2010; Transparency International, 2010).
Public decision making process	In the case of Kumtor, EIA was not subject to an open debate and it was not widely discussed at all.	Over 400 conditions put forward in the final approval of the Pascua-Lama project reflect the doubts and questions suggested by various stakeholders. This, in turn, reflects the relatively open and transparent decision making process in Chile. Still, the initial EIA that foresaw removing glaciers was approved in 2001.
Involvement of international NGOs	Major international environmental NGOs either not active in Kyrgyzstan or with low involvement. However, involvement of national and international stakeholders increased following the Kumtor sodium cyanide spill accident in 1998.	Presence of international environmental NGOs, coordinated actions, freedom of activity.
Economic situation	In 2000, Kyrgyzstan's GNI per capita was USD 280 (World Bank data). Throughout the 1990s, Kyrgyzstan struggled with economic recession.	In 2000, the Chilean GNI per capita was USD 4840 (World Bank data). Most of the 1990s was a period of significant economic growth.

(Continues)

	Kyrgyzstan	Chile
Significance of the project for national economy	Over the years of its operation, Kumtor mine contributed up to 10% to the country's GDP, up to 41% to its exports and up to 44% to its industrial production. Significant pit wall failures in 2002 and 2006 heavily impacted on the rate of economic growth in the country.	Although Pascua-Lama is supposed to become one of the largest gold/silver mines in the world, it still will not be 'the engine of a national economy'.
Character of the project	Until 2004, Kyrgyz government held 66% of shares in Kumtor Gold Company.	Pascua-Lama is operated by a single foreign company.
Reporting	Since 1999, Kumtor has printed a few copies of hardly accessible annual environmental reports. Very limited transparency which has improved only recently.	Barrick's reports plus intensive public relations work in response to reservations expressed by local populations and NGOs.
Additional circumstances	Mining takes place close to the source of one of the main rivers of Central Asia – Naryn (Syr-Darya). Thus, large-scale gold mining has been listed among the three most important environmental problems in Kyrgyzstan (OSCE, UNEP and UNDP, 2003), and consequently also in other Central Asian countries.	An emotionally written and rather imprecise chain email contributed worldwide attention to the issue.

Table 3. Differences between Kyrgyzstan and Chile that led to different approaches to mining glaciers

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to a far larger extent, demonstrates that mining can rarely provide additional motives for the protection of glaciers. Also, glaciers differ with regard to their geophysical properties, resulting in diversified vulnerability to climate change (smaller glaciers being more vulnerable). The values of individual glaciers are likely to be site specific and depend on a wide range of factors. Global warming affects the perceived values of glaciers to a far larger extent than mining (and it affects all glaciers), but, through its impact on glaciers, it also affects mining projects. On the one hand this refers to making some resources (previously covered with glaciers) more accessible, but on the other hand it may preclude (at least temporarily) access to other resources, because of potential public opposition to interfering with increasingly scarce glaciers. The latter reveals yet another example of a potential negative value of a glacier from the perspective of an individual company. The barrier to the development of a given project might not be as important in physical terms as it becomes in terms of public opposition and the resulting political and legal restrictions.

Conclusions

The decisions regarding Kumtor and Pascua-Lama mines were made in different economic and socio-political circumstances, which affected the opportunities for different stakeholders to reveal their preferences towards glaciers. The dynamics of environmental conflicts and environmental governance in general changes with the introduction of international stakeholders, and this is related to democratization. Although formally Kyrgyzstan is a democratic country, the political traditions and social legacy of long-term top-down policy make it very unlikely that an environmentally harmful activity would be revealed and contested. Although an opposition would be easier now because of wider access to information and larger opportunities for building international coalitions, the general economic and socio-political setting makes it still rather unlikely.

This indicates the importance of democratization and social empowerment for environmental governance. Giving local people more opportunities for participation and control, and empowering different social groups, would increase their bargaining power when confronted with international stakeholders representing narrow-minded economic interests. This would reduce the power discrepancy by facilitating the alliances of local resistance groups with more powerful international stakeholders. Problems such as global warming bring environmental issues to the attention of wide spheres of society in developed countries and potentially help local resistance groups in developing countries recruit partners to their coalitions. In such circumstances, gold mining can help to reveal societal preferences towards glaciers by drawing people's attention to the issue of glacier destruction and potentially eliciting the values they attach to glaciers. Thus, local resistance groups should target issues that appeal to values that are strong in developed countries, such as the symbolic and other non-use values of glaciers, and companies should avoid interfering with those values to save themselves the trouble. Furthermore, as these values are incommensurable, there is a need for value pluralism (Martínez-Alier, 2001) in studying and governing such situations.

The case studies analysed here point to the complicated role of the state in supporting economic development, and guaranteeing effective environmental regulation and participation. Estimating the value of glaciers and their services would facilitate other future decisions regarding interfering with glaciers. Indeed, contingent valuation studies might use mining as a potential scenario, asking respondents how much they would be willing to pay not to have a particular glacier mined. Referring to the value of glaciers, upstream countries might seek compensation from downstream countries for foregoing large-scale environmentally risky projects (Kronenberg, 2012). Countries with gold reserves under glaciers might seek compensation from gold using countries for foregoing projects affecting glaciers, based on the preferences revealed by stakeholders originating from the latter.

As new resources are being explored in areas where mining was previously not financially or politically viable, increased international scrutiny is necessary in studying the impacts of mining. Impacts on glaciers, and thus water availability in the future, should be incorporated in the relevant environmental impact assessments, cost–benefit analyses and life-cycle assessments. The relevant product information could be used in product-oriented environmental policies, in an attempt to make overseas consumers effectively reveal their preferences and choose gold whose extraction did not affect glaciers. Indeed, some jewellery companies have already started to cooperate with selected gold providers only, to ensure that the gold they buy is produced in a responsible manner (Diamond, 2005, p. 467). Lack of interference with glaciers might be used as yet another criterion in such procurement policies.

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