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Place re-making and sense of place after quarrying and social-ecological restoration

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Abstract

Rapid urbanization increases pressure on extracting construction materials through quarrying, which is disrupting and re-making places worldwide. In this study, we examine how people's place making and sense of place are reconfigured through quarrying. Taking a case study approach, we investigate perceptions of sense of place after quarrying and social-ecological restoration in a limestone region of the Czech Republic. Our survey of 400 visitors shows that quarrying affects sense of place through feelings, activities, and quarry features. These can be predicted by socio-demographic characteristics, experiences and preferences, and the context of a particular quarry. We conclude that sense of place and place making should be key themes of the sustainable development debate, as they help to better understand the human variables that constrain or enable socially just development. Our approach provides a conceptual basis for this by revealing the processes through which people iteratively recreate their connections to places shaped by long-lasting disruptions, such as mining and quarrying, that erased prior socio-cultural and material landscapes.

KEYWORDS
mining, place attachment, place making, social-ecological systems, sustainability, values

1 | INTRODUCTION

Over the past six decades, the planet has gone through a process of rapid urbanization. While the global rural population is expected to decline from 3.4 billion in 2018 to around 3.1 billion in 2050, the urban population is expected to increase from the current 4.2 billion in 2018 to 6.7 billion in the same period (Burger et al., 2020). These shifts in demographics, on one hand, put significant pressure on policy makers, planners, and architects to assure that the development will be sustainable. On the other hand, there are increasing demands on the extractive industries to deliver materials for supporting the construction of new settlements, industrial areas, and traffic infrastructure (Franks, 2020; UNEP, 2022).

Extracting materials through quarrying is a form of land development that, similarly to urbanization, disrupts and re-makes places (Bebbington & Bebbington, 2018). The extent of these disruptions and their prevention depends on the efficacy of regulatory interventions and the adaptive capacity of local communities (Svobodova et al., 2021). These capacities differ between places, regions, and countries (Owen et al., 2021).

At the same time, it is increasingly recognized that land development to be sustainable requires consideration of the local social-ecological ramifications through a place-based approach (Grenni et al., 2020; Ives et al., 2020; O'Brien, 2018; Riedy, 2016). To do so, the more visible physical dimensions of development need to be integrated with the less tangible interactions between people and places

(Masterson et al., 2017; Verbrugge et al., 2019). An understanding of residents' motivations to adapt and reconnect to a place after it has been disrupted or erased as well as their incentives to protect a place from its disruption is important for sustainability to be achieved across different environmental and social realities. For these reasons, the concepts of place making and sense of place are central to both the practical and theoretical dimensions of sustainable development.

This study examines concepts of place, place making, place re-making and sense of place in their relationships to a disruption of local settings and livelihoods caused by quarrying. Our central hypothesis is that quarrying disrupts dynamic interactions between people and places (place making) embedded in the places prior to quarrying. As quarrying interfaces with the places, it shapes and determines these interactions and creates new ones. The interface, at the same time, creates the context for place re-making where people interactively connect and reconnect to the places through their sense of place.

We explore this hypothesis in a case study where we investigate the sense of place as part of place re-making processes after quarrying and social-ecological restoration in a limestone region of the Czech Republic. The aim of this study is thus to analyze how the sense of place associated with eight restored and operating quarries is formed, expressed, and localized in the Czech Karst, an area wholly shaped by the legacies of limestone quarrying for over seven decades. In this study, we use a single survey to examine sense of place. Previous research (e.g., Cross, 2015; Hay, 1998; Tuttle, 2022; Von Wirth et al., 2016), that guided our approach, has shown that it is possible to study the connection between people and places at a specific point in time through an analysis of the unique characteristics and qualities of the place as well as people's personal experiences and knowledge. This approach serves as an alternative to longitudinal studies (e.g., Cuervo & Wyn, 2017; Long & Perkins, 2007).

We suggest that laying out the concepts of place, place making, place re-making and sense of place and demonstrating them in a case study can help build a theoretical framework for thinking about the relationships between disruptions, people, and sustainable development. As the sustainability agenda intensifies (UN DESA, 2022), understanding the composition of the dynamic interactions between people and places in locations undergoing large-scale transformations will be critical to designing and activating policy incentives. It will require policy makers to tackle some of the most difficult aspects of the sustainable development question: the social, economic, behavioral and psychological dimensions of individual decision making (Dempsey et al., 2011; Di Fabio & Rosen, 2018; Mensah, 2019; Zabel, 2005).

2 | CONCEPTS

When people interact with a place for the first time, they have a feeling of curiosity, excitement, or anxiety. If they enjoy the place and it has led to a positive emotion, then they will create a connection with the place. This connection between people and places has been a common theme across different branches of social and social-ecological science for decades (see literature reviews by Masterson et al., 2019 and Lewicka, 2011). Despite the long-term interest, concerns about the underlying theory of the relationship between industrial development and a place remain unresolved. In the first part of this section, we discuss conceptions of place, place making, re-making and sense of place. The second part conceptualizes quarrying in terms of place re-making. The final part introduces the perspective on social-ecological restoration as a place re-making process after quarry closure or abandonment.

2.1 | Place, place making, and sense of place

The concept of "place" is necessarily problematized by the many and varied understandings in the literature. Relph (1976) and Tuan (1974) introduce the classic way that defines places as stable, bounded and historically continuous entities. On the other hand, authors such as Massey (1991, 1994, 1995) and Harvey (1996) define places in a relational perspective as nodes or networks that are interlinked through scales of human interactions. Similar to the latter view, Low and Altman (1992) see places as contexts of interpersonal, community, and cultural relationships.

Places are closely related to the livelihoods in those places, identities of the region and communities living there. When livelihoods or regions are in transition, places are likely to be in processes of transformation as well (Bebbington, 2000). This dynamic nature of places coheres with the views of Pierce et al. (2011) who argue that rather than speak of "place" we should speak of "place making." In their view, place making is "a set of social, political and material processes by which people iteratively create and recreate the experienced geographies in which they live" (Pierce et al., 2011 p. 54). Place making is dynamic, hybrid, and multi-actor and refers to how people enact a place, both physically and socially (Cartel et al., 2022). According to Bebbington and Bebbington (2018), the set of processes of place making is always negotiated among actors with asymmetric relationships and inequalities of power across different scales. These asymmetries couple with efforts to manage, resist and negotiate them. If the asymmetries cause a disruption of the place making process, the new realities brought by the change necessarily lead to re-making of the place. In some cases, the disruption can be drastic and occur through the erasure of prior socio-cultural and material landscapes (e.g., opening a mine or community resettlement). The erasure drives communities to re-value and re-connect to the disrupted places to give them new or rediscovered meanings and symbolic significance (Bainton et al., 2012). Place re-making is driven by the same social, political, and material processes as place making (see Pierce et al., 2011) framed by the long-lasting consequences of the disruption.

Sense of place plays a critical part in the place making process. According to Wilkie and Roberson (2010), sense of place is a driver not only for representing and imagining places but for creating and contesting them in the process of place making and re-making. The concept of sense of place has been adopted in many disciplines to

study human behavior in relation to the physical environment. However, sense of place is not a unified concept (Lewicka, 2011; Raymond et al., 2017). It has been operationalized and measured in multiple ways with different methods and tools. Some studies examine sense of place as an outcome variable (e.g., Groulx et al., 2014; Lavigne et al., 2008; Ruiz & Hernández, 2014), while others consider it as a predictor or intervening factor (e.g., Ratcliffe & Korpela, 2016; Sullivan & Young, 2020). Dear and Wolch (1989) define sense of place as a dynamic and complex phenomenon containing different physical, social and time dimensions across different places and scales. It can incorporate many inseparable, integral, and mutually defining components, predictors, qualities and properties (Low & Altman, 1992). Lowenthal (1961), for example, sees the people-place relationship as consisting of people's direct experience, memory, fantasy, present circumstances, and future purposes. Scannell and Gifford (2010) in their tripartite framework define sense of place as a construct of three interconnected dimensions: person, psychological processes, and place. According to Stedman (2003), sense of place contains four related characteristics: a place, activities related to the place, meanings and attachments connected to human experiences in the place and psychological connections to the place.

Socially constructed expectations, or the norms and values that are shaped and influenced by society, can play a significant role in how people perceive and think about various places (Jenkins et al., 2016), including quarries and mines. For example, the way that traditional and social media portray mining activities can create a mental image of what mining is like, and this image can shape how people view and engage with mines and quarries. According to Olafsson et al. (2021), social media can facilitate, communicate, and mediate people–place interactions through affect, cognition and practice, and thereby shape senses of place.

People can connect to all places that are a source of meanings and emotions, whether liked or disliked (Riley, 1992). To map these attachments, sense of place has been studied in different types of landscapes, for example, protected and heritage sites (Woosnam et al., 2018), rural landscapes (Lokocz et al., 2011), and urban natural areas (Ryan, 2005). Fewer authors (e.g., Goin & Raymond, 2001; Mah, 2009; Mondal & Mistri, 2021; Phillips & Murphy, 2021; Svobodova et al., 2021) paid attention to mine-affected landscapes containing industrialized features. We argue that sense of place may become most impactful exactly in these landscapes.

In our approach, we understand sense of place as a concept fully shaped by individuals' perceptions and expressions of the place, and we conceptualize sense of place as a dynamic system of predictors and components. We differentiate three sense of place components: (i) people's feelings about the place, (ii) their activities related to the place, and (iii) place characteristics as perceived by people. These components are interconnected and tied up together with three predictors: person (socio-demographic characteristics), process (experience and preferences) and place (quarry) to work in a dynamic system that we term a *sense of place bundle*. This conceptualization of sense of place in bundles of predictors and components is guided by our previous research and demonstrated by Svobodova et al. (2021).

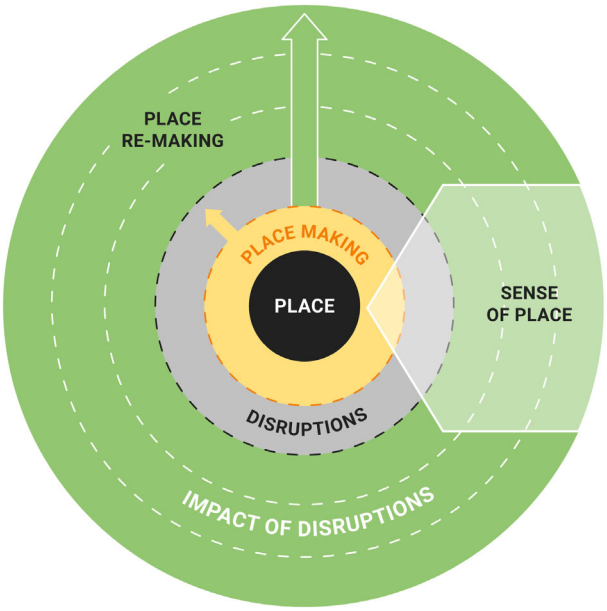

FIGURE 1 The relationships between the concepts of place, place making, place-remaking, and sense of place in the context of disruptions and their long-lasting impacts.

We define relationships between place making, place re-making and sense of place as described in Figure 1. While place making and re-making are processes by which people interactively create and recreate places where they live and visit, sense of place is an inseparable part and a driver of these processes. Through sense of place, people connect to places in their place (re)making processes.

2.2 | Quarrying as disruption and place re-making process

Quarries are open cast excavations from which deposits of hard or soft rocks are extracted using rock drills or explosions of dynamite (Coppin & Bradshaw, 1982). In the European Union, mining and quarrying were estimated to use 0.2% of the land in 2003, compared with 2.0% for transportation infrastructure, 2.3% for residential, and 41.5% for agriculture (EUROSTAT, 2003). Even though the spatial impact of the industry seems rather low, quarrying activities often leave long-term social, economic, and environmental disruptions in places where the deposits are extracted (Bendixen et al., 2021; Svobodova & Hajek, 2017). Environmental disruptions resulting from the excavation are diverse in scale and character (Salgueiro et al., 2020). They include loss of habitats, change in natural water systems near or downstream from a quarry, soil erosion, noise, vibration, and dust pollution (Lad & Samant, 2014). These disruptions may lead to conflicts between quarrying companies and local communities, revolving around their mitigation, community self-determination, resource control, and land use competition (Hilson, 2002). On the other hand, Baczyńska et al. (2018) argue that quarries, besides their negative impacts, possess

topographical uniqueness, educational values, and cultural significance. Quarries may contribute to regional identity and significance (Bloxam, e.G., 2009), support tourism (Stefano & Paolo, 2017), promote geoheritage, and geoscientific education (Beranová et al., 2017), become sport and cultural venues (Chang & Chiou, 2007) and host unique wildlife habitats (Davis, 1979).

Quarrying occurs in places embedded in networks of social relations, in places that were being made through the layering of human activities prior to, during, and after the quarrying ceased. These interactions between the place and quarrying are the context for place re-making. When quarrying disrupts the places, it also intersects with the diverse decisions and livelihoods as part of everyday place making (Castillo & Brereton, 2018). Some people may gain from the development, while others may lose—leading to complex processes of place re-making. The mining industry becomes a conscious agent in this process as it is able to change the contemporary experience of the place and shape its future place re-making through the restoration of the post-mined land.

Bebbington and Bebbington (2018) see mining and quarrying as particular forms of land development. This development disrupts and re-makes places. Central to these processes of disruption and re-making are new flows and movements, consisting of materials, finance, people, their attachments and perceptions. Quarrying is an immensely disruptive activity that, whether large scale or small scale, introduces new flows into and out of the place in which it occurs. The flows may change certain material and cultural aspects of the place, stabilize other aspects, and trigger the creation of new ones (Bainton et al., 2018). The character and intensity of these flows shape the nature and the identity of the place and place re-making. According to Anguelovski (2014), effective place re-making capitalizes on the physical, cultural, and social identities that define a place.

2.3 | Social-ecological restoration as place re-making toward natural values

By its very nature, social-ecological restoration entails a change to a place of a quarry and to the variety of activities and benefits provided by that place. It is the restoration as a re-making process that enables people to collectively reimagine, reinvent, and physically reconnect with the place of the quarry.

In this article, we approach restoration after quarrying from an interdisciplinary perspective of social-ecological systems, as reflected in the United Nations Decade on Ecosystem Restoration 2021–2030 (United Nations Environment Agency, 2019). In this perspective, social-ecological restoration is defined as "the process of human assisting the recovery of a degraded, damaged, or destroyed ecosystem to reflect values regarded as inherent in the ecosystem and to provide goods and services that people value" (Martin, 2017). According to Fischer et al. (2021), most of the global ecosystems have coevolved with social systems. Restoration of these ecosystems, therefore, accounts for social-ecological coevolution in the past and creates opportunities for ongoing social-ecological coevolution in the future.

In the absence of human assistance in the recovery, abandoned quarries undergo a process of ecological (spontaneous) succession (Prach & Hobbs, 2008). In its simplest terms, ecological succession refers to ecosystem change where one group of organisms at a given site is replaced by others as time advances (Wali, 1999). Each ecosystem hosts certain conditions that subsequently allow different species to thrive. Gradually, these species replace one another until a climax is reached (e.g., a mature forest) or until a disturbance occurs. We argue that social-ecological restoration with a high level of ecological succession may be considered as a place re-making process driving quarries toward "new" natural areas. This place re-making makes natural values and benefits accessible to local communities, and shapes people's construction of place meanings, pluralistic place values and their transformation (Williams et al., 2002). Through the place re-making process, the communities create and contest specific values and meanings from their relationship with the "new nature." These meanings, in turn, structure their social actions related to the quarries (Chan et al., 2016).

We posit that social-ecological restoration of a quarry is a mechanism for place re-making toward nature-related values. At the same time, sense of place is a key driver of this place re-making process. In this article, we focus on sense of place as part of place re-making after the disruptions associated with quarrying. We suggest that sense of place is an appropriate framework to analyze how people, through their perceptions, activities, and feelings, relate to quarries after decades of place re-making through the social-ecological restoration with prevailing ecological succession. Our approach contributes to "recasting ecosystem restoration as a social-ecological endeavor" (Fischer et al., 2021 p. 20).

3 | METHODS

The case study presented in this article explores sense of place as part of place re-making processes after quarrying and social-ecological restoration. In the study, we analyze the interactions between sense of place predictors and components inside the sense of place bundles.

3.1 | Study area

The case study is placed in the Czech Karst, covering an area of 132 km^2. Located southwest of the capital city of Prague, the Czech Karst is the largest limestone and karst region in the Czech Republic and a geological territory of global significance with almost 700 caves (Míka, 2022). In 1972, the protected landscape area (PLA) of the Czech Karst was designated to protect the unique landscape, esthetic and natural values and typical cultural features of the region.

The first mineral extraction in the Czech Karst dates back to the Middle Ages. It reached a great boom in the 14th century when limestone became an important raw material for construction (Brunnerová, 1974). The largest development of mining in the Czech Karst occurred at the end of the 19th century, supporting the increase in Prague's large-scale

metallurgical production of iron and steel. In the first half of the 20th century, mining was mechanized and production increased in the quarries of Malá Amerika, Mexico and especially Velká Amerika. In the second half of the 20th century, mining in the quarries was reduced as a result of the decline in iron industries and the quarries were gradually closed and abandoned. Currently, there are five operating quarries in the PLA. In 2019, the extraction of minerals in the Czech Karst was over 3293 kilotons with Silurian and Devonian high-percentage limestones as the most mined in the area (Starý et al., 2020). The population living in the PLA is about 10,000 people with a population density of about 70 persons per km^2 (Nature Conservation Agency of the Czech Republic, 2018).

With the declaration of the PLA in 1972, there was a shift from agricultural and industrial resource extraction to nature protection and recreation in the Czech Karst. Many quarries have subsequently become the subjects of nature and cultural protection, representing unique and rare habitats for endangered species, which are rapidly disappearing from rural landscapes (Beneš et al., 2003; Novák & Prach, 2003). New geological outcrops created during mining became important localities to study rock environments, such as cave systems (Beranová et al., 2017).

Eight quarries were selected for our study: Čertovy Schody (1), Houbův lom (2), Na Kobyle (3), Solvaovy lomy (4), Na Chlumu (5), Alkazar (6), Velká Amerika (7), and Malá Amerika (8). While Čertovy Schody is the only operating quarry in the study with some parts under reclamation, the remaining seven quarries were abandoned approximately 50 years ago. Ecological succession in the quarries has been partially controlled by designed interventions undertaken by the PLA administration, including the removal of invasive species. Figure 2 and Table 1 provide an overview of the eight localities.

3.2 | Sampling, data collection, and data analyzes

The case study was designed using quantitative data collection. Target participants were visitors to the PLA Czech Karst who visited one of

FIGURE 2 Study area of the Czech Karst and the eight quarries where the field data collection was conducted.

TABLE 1 Description of the eight study quarries, including coordinates, mining stage, closure year, number of pits, presence of a pit lake and approximate size

#	Locality name	Coordinates	Mining stage	Mining closure year	Number of pits	Pit lake	Approximate size (length x width; depth walls + water)
1	Čertovy Schody	49.9106717 N, 14.0681236 E	Operating, restored partially (edges)	Not specified	2	No	2000 x 900 m; 300 m
2	Houbův lom	49.9147139 N, 14.0670583 E	Closed, left to spontaneous succession	1950	1	No	280 x 180 m; 55 m
3	Na Kobyle	49.9129264 N, 14.0810547 E	Closed, left to spontaneous succession	1929	1	No	300 x 160 m; 45 m
4	Solvayovy lomy	49.9766144 N, 14.1485100 E	Closed, left to spontaneous succession	1956	3	No	800 x 240 m; 45 m
5	Na Chlumu	49.9461603 N, 14.1340078 E	Closed, left to spontaneous succession	1955	1	No	270 x 240 m; 60 m
6	Alkazar	49.9506269 N, 14.1239564 E	Closed, left to spontaneous succession	1943	1	No	300 x 85 m; 60 m
7	Velká Amerika	49.9601642 N, 14.1997953 E	Closed, left to spontaneous succession	1964	1	Yes	750 × 150 m; 80 + 70 m
8	Malá Amerika	49.9545178 N, 14.1760375 E	Closed, left to spontaneous succession	1964	1	Yes	165 x 57 m; 30 + 15 m

the eight study quarries and were questioned in the quarry. When selecting participants for our study, purposive sampling was applied to receive a gender-balanced sample of participants of various ages. We used a paper questionnaire suitable for the data collection directly in the field.

The questionnaire was anonymous and divided into three thematic parts that were introduced by a short text containing the aim of the study, the introduction of the research team and instructions for the completion. The first part of the questionnaire included questions on the socio-demographic characteristics of the participants (gender, age, education, occupation, and place of residence). The second part focused on participants' experience with the Czech Karst and their perception of quarrying. We asked about the frequency of their visits to the area and their recommendations of other places to see in the Czech Karst. Questions on their perception about quarrying included their post-mining land use preferences and their experience with quarrying in the Czech Karst or elsewhere. The last part of the questionnaire explored participants' sense of place related to the quarry where the survey was undertaken. We asked how visitors interact with the place, what they value in the place and how they feel about it. Participants reported activities they conducted in relation to the quarry (e.g., geocaching, hiking, and climbing) as well as features of the place they valued (e.g., unique flora and fauna, unique industrial features). To measure their feelings about the quarry, we used a Likert scale ranging from −2 to +2 as follows: −2 "I don't feel about it this way at all," −1 "I don't feel about it this way," 0 "I am not sure how I feel," +1 "I feel about it this way," +2 "I completely feel about it this way." The feelings were divided into 11 categories: enjoyable, safe, intriguing, beautiful, relaxing, romantic, diverse, contrasting with the surroundings, benefiting nature, benefiting communities, and rewarding.

Data collection was conducted in the quarries or in their close proximity with a view to the quarry (if the quarry was inaccessible). The survey ran on weekdays and weekends from August to October 2017 to include a broad spectrum of visitors. A total of 400 visitors to the eight quarries participated in the survey (50 visitors per quarry). All participants were Czech citizens and the survey language was Czech. To protect participants' privacy and rights, informed consent was obtained verbally and published excerpts were anonymized.

The collected questionnaires were transcribed and organized in a database. Open and semi-open questions (i.e., place of residence, recommended places to visit, activities conducted in relation to the quarry and valuable physical settings of the quarry) were transcribed in full and analyzed using qualitative focus coding, including labeling, and defining categories. Categories emerging from participants' responses to the "sense of place" questions were termed *sense of place components* (dependent variable). They included 12 variables of participants' feelings about the quarries, five of their activities conducted in relation to the quarries and five of the features they valued there (Table 2). The variables of activities and features were coded as "1" (identified) and "0" (unidentified) for each participant. Variables of feelings were re-coded to a positive scale "1" (equal to −2) to "5" (equal to +2). Socio-demographic characteristics of participants, their experience with the Czech Karst and their perception of quarrying as well as the locality (quarry) were termed *predictors* and served as independent variables.

To analyze interactions between the sense of place predictors and sense of place components, we performed Mann–Whitney U test and Kruskal-Wallis H test, which identified statistically significant differences between independent and dependent variables. The Dunn's post hoc pairwise test was used following a significant Kruskal-Wallis test to identify differences within levels. We applied

TABLE 2 Dependent (DV) and independent (IV) and the proportion of the sample within variable categories

Predictors (IV)	Categories (code; percentage in the sample)
Socio-demographic characteristics	
Gender	Male (1; 48%); female (2; 52%)
Age	20 years and younger (1; 11%); 21–35 years (2; 33%); 36–50 year (3; 29%); 51–64 years (4; 17%); 65 years and older (5; 10%)
Education	Vocational school and lower (1; 25%); high school (2; 42%); university and professional training college (3; 33%)
Occupation	Nature protection, mining, tourism (1; 20%); retirement, unemployment, maternity leave, student (2; 14%); others (3; 66%)
Region	Prague, Central Bohemian region (1; 41%); other regions (0; 59%)
Experience and preferences	
Closure preferences	A final void will be filled up, forests, fields and meadows will be created (i.e., planned technical reclamation) (1; 8%); a final void will be rebuilt into a water reservoir (i.e., planned technical reclamation) (2; 22%); a final void will be left to nature without significant human intervention (i.e., natural restoration) (3; 44%); a final void will be left only partly for nature, for example, only some trees and bushes will be planted (i.e., controlled natural restoration) (4; 27%)
Recommendation on quarry	No quarry recommended (0; 15%); 1 quarry recommended (2; 44%); 2 quarries recommended (3; 24%); 3 and more quarries recommended (4; 17%)
Quarry perception	Quarries are typical features of the Czech Karst (1; 84%); quarries are not typical features of the Czech Karst (2; 8%); do not know (0; 8%)
Quarry visit	Never (1; 19%); 1–3 times (2; 41%); more than 3 times (3; 41%)
Czech Karst visit history	Less than 10 years (1; 60%); last 10–30 years (2; 28%); more than 30 years (3; 12%)
Czech Karst visit frequency	First visit—First time visitor (1; 32%); every second year and less—rare and irregular visitor (2; 31%); 1–3 times a year (3; 20%); more than 3 times per year—frequent visitor (4; 17%)
Quarry	
Locality	Čertovy Schody (1; 13%); Houbův lom (2; 13%); Na Kobyle (3; 13%); Solvayovy lomy (4; 13%); Na Chlumu (5; 13%); Alkazar (6; 13%); Velká Amerika (7; 13%); Malá Amerika (8; 13%)
Sense of place components (DV)	
Feelings about quarries	
Enjoyable	−2 (1%); −1 (3%); 0 (9%); +1 (31%); +2 (56%)
Safe	−2 (6%); −1 (18%); 0 (22%); +1 (36%); +2 (18%)
Intriguing	−2 (1%); −1 (3%); 0 (18%); +1 (46%); +2 (32%)
Beautiful	−2 (1%); −1 (4%); 0 (12%); +1 (33%); +2 (50%)
Diverse	−2 (1%); −1 (3%); 0 (16%); +1 (50%); +2 (30%)
Relaxing	−2 (3%); −1 (5%); 0 (18%); +1 (31%); +2 (43%)
Romantic	−2 (5%); −1 (5%); 0 (14%); +1 (35%); +2 (41%)
Contrasting with surroundings	−2 (4%); −1 (6%); 0 (20%); +1 (37%); +2 (33%)
Benefiting nature	−2 (4%); −1 (7%); 0 (16%); +1 (35%); +2 (38%)
Benefiting communities	−2 (4%); −1 (5%); 0 (25%); +1 (34%); +2 (32%)
Rewarding	−2 (1%); −1 (3%); 0 (20%); +1 (43%); +2 (33%)
Activities	
Climbing	0 (97%); 1 (3%)
Swimming	0 (95%); 1 (5%)
Geocaching	0 (93%); 1 (7%)
Hiking and cycling	0 (80%); 1 (20%)
Quarry features	
Nature and geology	0 (56%); 1 (44%)
Cultural and industrial features	0 (79%); 1 (21%)
Unique flora and fauna	0 (82%); 1 (18%)
Atmosphere	0 (54%); 1 (46%)

non-parametric tests as the dependent variables were not normally distributed.

4 | RESULTS

4.1 | Interactions inside the sense of place bundles

Different sense of place components were significantly affected by different predictors, as shown by the Mann–Whitney U and Kruskal-Wallis H tests. While the locality (quarry) was the strongest predictor affecting most of the sense of place components, the impact of other predictors differed. The way that visitors reported their feelings was in large impacted by their experience and preferences in regard to quarrying in the Czech Karst and elsewhere. The activities conducted in relation to the quarries and the appreciated features of the quarries were mainly affected by their visiting history and frequency in the Czech Karst.

The Sankey Diagram (Figure 3) presents the statistically significant linkages inside the sense of place bundles where different predictors affect different components with different significance. Disaggregating the bundles shows what factors influence individual place making, meaning how individuals perceive a quarry and how they feel about it.

In the following paragraphs, we disentangle the bundles to present our findings on how the sense of place components are associated with each of the three predictors. We present only statistically significant results ($p \leq .05$). Details on the results of Dunn's post hoc pairwise test are listed in Supplement 1.

4.2 | Socio-demographic characteristics

Our analyzes showed that **gender** significantly affected how visitors reported their feelings of safety related to the quarries. In general, men felt safer than women (U (2) = 20,160; $Mean_{Men} = 0.59$; $Mean_{Women} = 0.26$; $p = .006$).

Education had significant effect on visitors' feelings of diversity (H (2) = 6.606; $p = .037$), relaxation (H (2) = 7.542; $p = .023$) and romantic feelings (H (2) = 6.220; $p = .045$) related to the quarries, with statistically significant differences between the education levels. Visitors with higher education reported these feelings significantly more often than visitors with lower education.

Age influenced how visitors reported about their rewarding feelings when being around the quarries (H (4) = 12.871; $p = .012$). Visitors aged 65 years and older felt more rewarded than younger visitors. Visitors' choice of geocaching as an activity related to the quarries was also affected by their age (H (4) = 22.103; $p < .0001$). Younger visitors under 35 years reported geocaching as their reason to come to the quarry significantly more often than others. On the other hand, the older groups of visitors reported cultural and industrial features as valuable characteristics of the quarries (H (4) = 9.760; $p = .045$) more often than the youngest group.

The feelings of safety were significantly associated with the visitors' **occupation** (H (2) = 19.552; $p < .0001$). Visitors who reported

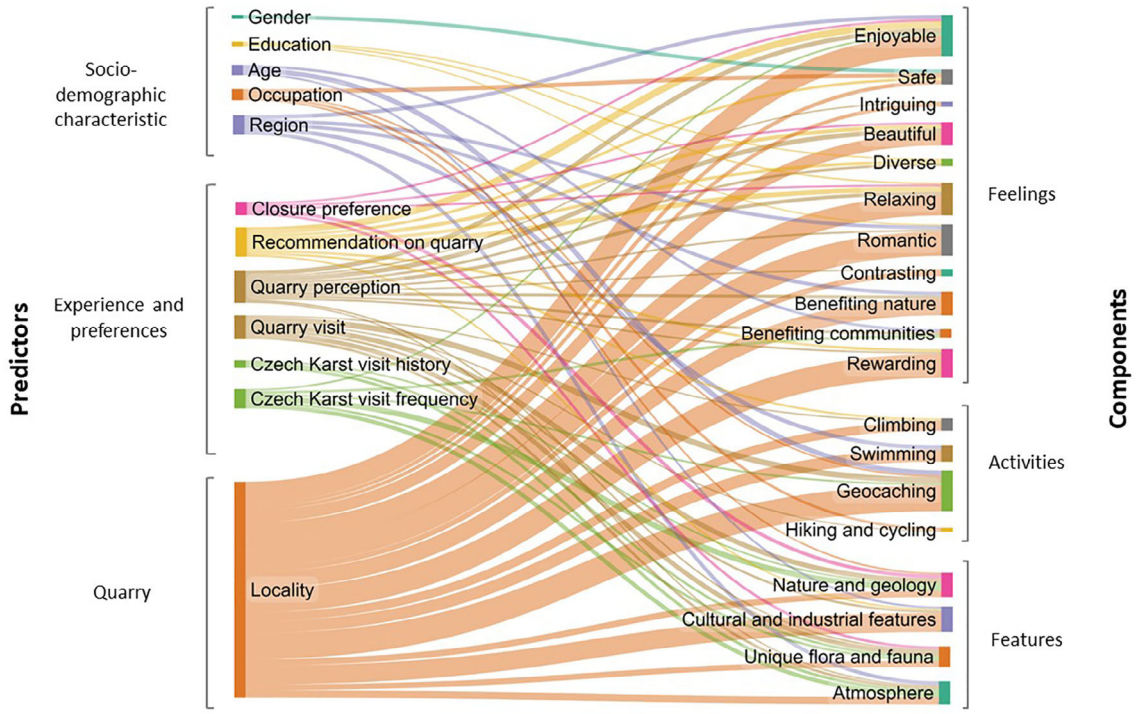

FIGURE 3 Participants' sense of place bundles as revealed in the survey. The Sankey Diagram indicates those sense of place bundles that contain statistically significant relationships between the predictors and components of sense of place.

they are employed (groups 1 and 3) felt safer about the quarries significantly more than 'unemployed' groups of visitors (group 2). The occupation influenced visitors' choice of activities related to the quarries, with significant associations with geocaching (H (2) = 8.434; $p = .015$) and trail walking and cycling (H (2) = 12.325; $p = .002$). The unemployed group of visitors reported that they come to walk and cycle around the quarries significantly more often than the employed groups of visitors. Visitors working in nature protection, mining, tourism, and unemployed groups of visitors reported they come to do geocaching in the quarries significantly more often than visitors with other jobs. Employed visitors reported that they valued nature and geology of the quarries significantly more often than the unemployed group of visitors (H (2) = 8.328; $p = .016$).

In terms of participants' home **region**, visitors from Prague and the Central Bohemian region (grouped as locals) reported stronger sense of place components than visitors from other regions of the Czech Republic. Locals reported that they felt about the quarries as romantic (U = 16,737; $p = .013$) and enjoyable (U = 17,353; $p = .044$) significantly more often than visitors from other regions. They felt that the quarries benefit nature (U = 16,439; $p = .006$) and valued the atmosphere of the quarries more than others (U = 21,967; $p = .009$). The locals further reported that they came to swim in the quarries significantly more often than others (U = 20,272; $p = .030$).

4.3 | Experience and preferences

Quarry closure preferences of visitors significantly impacted how they felt joy (H (3) = 10.311; $p = .016$), beauty (H (3) = 10.106; $p = .018$) and relaxation (H (3) = 9.025; $p = .029$) in relation to the quarries. Visitors who preferred planned technical reclamation found quarries significantly less enjoyable than participants who preferred other types of restoration. The closure preferences were found in significant associations with visitors' appreciation of quarry features such as unique flora and fauna (H (3) = 12.213; $p = .007$) and nature and geology (H (3) = 16.064; $p = .001$). Visitors who preferred natural restoration over other types of closure, valued these features significantly more than others.

Visitors' feelings of joy (H (3) = 30.611; $p < .0001$), safety (H (3) = 12.814; $p = .005$), beauty (H (3) = 17.540; $p = .001$), diversity (H (3) = 14.562; $p = .002$), relaxation (H (3) = 22.915; $p < .0001$) and reward (H (3) = 12.249; $p = .007$) were significantly associated with their **recommendations** on other places in the Czech Karst. Visitors who recommended visiting other quarries reported these feelings significantly more often than others. Climbing as an activity visitors relate to the quarries was also significantly associated with their recommendations to visit other quarries (H (3) = 9.599; $p = .022$). Visitors recommending more than two other quarries reported climbing more often than those who did not recommend a quarry at all. Furthermore, cultural and industrial features were reported as valuable by participants with quarry recommendations significantly more often than by others (H (3) = 8.102; $p = .044$). The recommendation predictor serves as a proxy for the knowledge of the area.

The perception of quarries as typical features of the Czech Karst was a strong predictor of all visitors' feelings about the quarries, except for safety. Visitors who agreed that quarries were typical features of the Czech Karst felt about quarries as enjoyable (H (2) = 20.536; $p < .0001$), intriguing (H (2) = 6.858; $p = .032$), beautiful (H (2) = 21.277; $p < .0001$), diverse (H (2) = 11.620; $p = .003$), relaxing (H (2) = 16.357; $p < .0001$), romantic (H (2) = 9.056; $p = .011$), contrasting with the surroundings (H (2) = 6.914; $p = .032$), rewarding (H (2) = 8.726; $p = .013$), benefiting nature (H (2) = 13.780; $p = .001$) and benefiting communities (H (2) = 11.780; $p = .003$) significantly more often than other visitors. These visitors further valued the atmosphere of quarries significantly more than those neutral in their perception (H (2) = 6.525; $p = .038$). On the other hand, visitors with neutral opinions reported flora and fauna as a value significantly less often than visitors with negative and positive opinions (H (2) = 7.751; $p = .021$).

Visitors' **previous experience with a quarry** was found in significant association with their activities related to the quarries. Visitors who have never visited a quarry before reported geocaching (H (2) = 25.884; $p < .0001$), hiking and cycling (H (2) = 6.529; $p = .038$) and climbing (H (2) = 6.692; $p = .035$) as their target activities significantly more often than visitors with previous quarry experience. Participants who have visited a quarry before, on the other hand, reported that they valued features such as atmosphere of the quarries (H (2) = 12.227; $p = .002$), unique flora and fauna (H (2) = 20.557; $p < .0001$), cultural and industrial features (H (2) = 10.955; $p = .004$) and nature and geology (H (2) = 21.952; $p < .0001$) significantly more often than those without this experience. The higher number of previous visits to a quarry, the higher frequency of reporting these values.

Visit history of the Czech Karst significantly influenced visitors' appreciation of quarry features. Participants who have been visiting the Czech Karst for more than 10 years reported they valued the atmosphere of the quarries (H (2) = 13.906; $p = .001$) and their nature and geology (H (2) = 7.859; $p = .020$) significantly more often than participants with shorter visit history. Furthermore, participants who have been visiting the Czech Karst for more than 30 years valued flora and fauna in the quarries significantly more often than others (H (2) = 11.509; $p = .003$).

Visit frequency of the Czech Karst was shown as the most influential on visitors' appreciation of quarry features. Nature and geology (H (3) = 24.683; $p < .0001$), atmosphere (H (3) = 18.511; $p < .0001$) and unique flora and fauna (H (3) = 11.558; $p = .009$) were valued significantly less by first time visitors than by others. Rare and irregular visitors valued nature and geology significantly more than frequent visitors and locals. Regarding visitors' feelings, frequent visitors and locals found the quarries significantly more enjoyable than rare visitors and first-time visitors (H (3) = 8.932; $p = .030$). On the other hand, first time visitors, frequent visitors and locals found the quarries as benefiting communities significantly more than rare and irregular visitors (H (3) = 12.509; $p = .006$). In terms of activities, geocaching was reported by first time visitors significantly more often than by rare and regular visitors (H (3) = 9.195; $p = .027$).

4.4 | Quarry

Participants reported positive feelings about Čertovy Schody (#1), the only operating quarry in the study, significantly less frequently than about other quarries in the Czech Karst. Visitors reported the lowest ratings for most of the studied feelings: enjoyable ($H(7) = 92.644$; $p < .0001$), safe ($H(7) = 17.133$; $p = .017$), intriguing ($H(7) = 16.544$; $p = .021$), beautiful ($H(7) = 52.578$; $p < .0001$), relaxing ($H(7) = 87.393$; $p < .0001$), romantic ($H(7) = 105.247$; $p < .0001$), contrasting ($H(7) = 24.761$; $p = .001$), benefiting nature ($H(7) = 72.355$; $p < .0001$) and benefiting communities ($H(7) = 40.043$; $p < .0001$). For feelings such as safe, romantic, benefiting nature and benefiting communities, the participants even provided negative ratings, the only negative ratings in the study. On the other hand, the quarry Velká Amerika (#7) received the highest average ranking, with the highest values for feelings such as enjoyable, beautiful, relaxing, and romantic. Figure 4 shows average values for each feeling per quarry presented in a radar chart.

In terms of other sense of place components, the Kruskal-Wallis H test showed statistically significant differences between the quarry predictor and all features that visitors valued in the quarries, and between the predictor and three out of four activities conducted in relation to the quarries (Table 3). While most of the visitors reported nature, geology, and atmosphere as the features they like about most of the quarries, cultural, industrial features and unique fauna and flora were reported as values in only a few of them. Geocaching was the most common activity reported across the study area, with Velká Amerika (#7) being the hotspot.

5 | DISCUSSION

In this article, we analyze sense of place as a key element and driver of place re-making after a place has been exposed to quarrying. Similar to Bebbington and Bebbington (2018), we conceptualize quarrying as an immensely disruptive activity that interfaces with places and introduces new flows into and out of the places, and in so doing creates the context for individual and collective place re-making. In our conceptualization, we highlight that it is crucial to understand how an individual sense of place may be transformed and adapted in response to the change in physical settings. At the same time, it is critical to understand the structure of the sense of place in driving individual and collective adaptation to changing physical settings, as previously demonstrated by Nalau and Cobb (2022), Barnes et al. (2020) and Scannell and Gifford (2013) in climate change adaptation frameworks.

In our case study, we use the sense of place bundles to analyze and test the theoretical concepts underlying this paper. This enables us to move from a philosophical to a practical perspective. While the quarry predictor in the sense of place bundles symbolizes the physical place and the disruptive impacts of quarrying on the places, predictors of experience and preferences relate to the time and knowledge dimensions of the people's evaluation of and connecting to the disrupted places. The sense of place components present individual drivers of people's place making and place re-making processes, meaning how people feel about the quarries, how they use them and what features of the quarries people like.

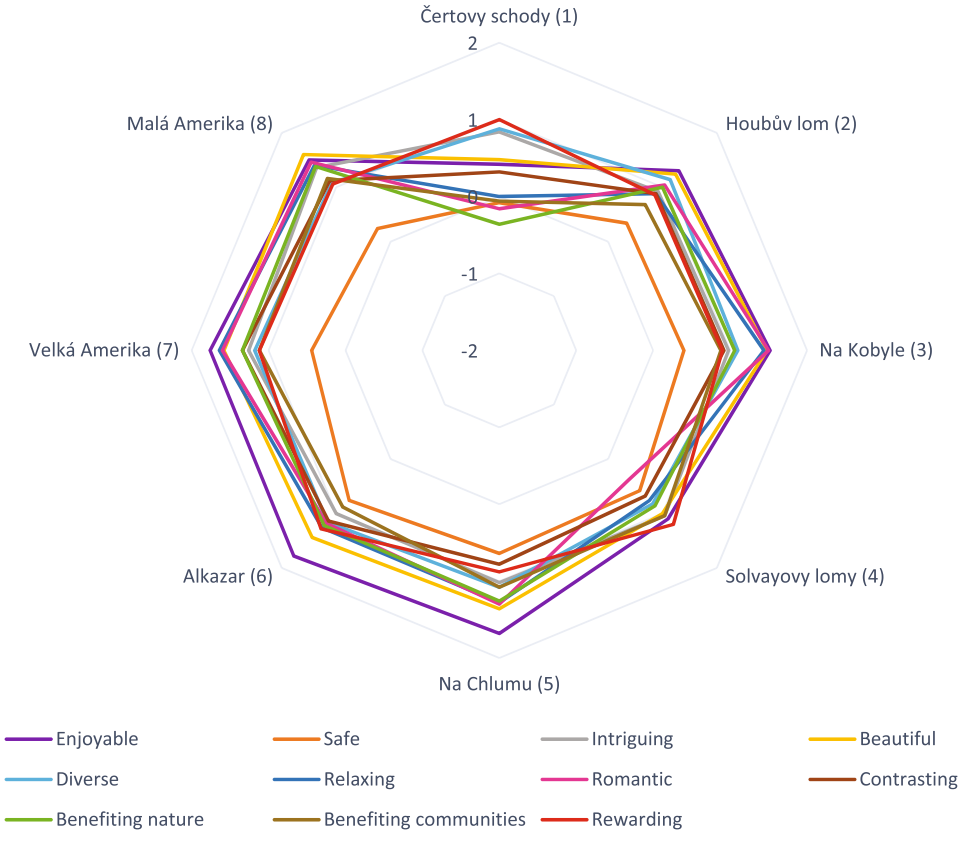

FIGURE 4 Feelings about the eight study quarries. The chart shows the average ratings reported by 400 visitors of the Czech Karst in our survey.

TABLE 3 Panel A shows absolute frequencies of quarry features and activities in each of the study quarries. Panel B presents average ratings of the feelings in each of the study quarries

Panel A:

	Absolute frequencies						
	Features				Activities		
Quarry	Nature and geology	Cultural and industrial features	Unique flora and fauna	Atmosphere	Climbing	Swimming	Geocaching
Kruskal-Wallis H	*27.728*	*83.179*	*25.536*	*32.447*	*38.392*	*52.689*	*114.062*
p	*.000*	*.000*	*.001*	*.000*	*.000*	*.000*	*.000*
1–Čertovy Schody	17	18	3	12	0	0	0
2–Houbův lom	31	11	14	28	0	2	2
3–Na Kobyle	22	6	15	29	0	0	2
4–Solvayovy lomy	22	31	3	22	0	1	1
5–Na Chlumu	24	3	11	31	3	0	0
6–Alkazar	22	4	6	25	8	1	0
7–Velká Amerika	9	2	5	11	0	2	21
8–Malá Amerika	30	7	14	26	1	12	1

Panel B:

	Average rating								
	Feelings								
Quarry	Enjoyable	Safe	Intriguing	Beautiful	Relaxing	Romantic	Contrasting	Benefiting nature	Benefiting communities
Kruskal-Wallis H	*92.644*	*17.133*	*16.544*	*52.578*	*87.393*	*105.247*	*24.761*	*72.355*	*40.043*
p	*.000*	*.017*	*.021*	*.000*	*.000*	*.000*	*.001*	*.000*	*.000*
1–Čertovy Schody	0.42	−0.08	0.84	0.48	0	−0.16	0.32	−0.36	−0.06
2–Houbův lom	1.3	0.34	0.92	1.24	0.88	1.04	0.88	1	0.68
3–Na Kobyle	1.52	0.4	0.98	1.48	1.44	1.5	0.92	1.06	0.88
4–Solvayovy lomy	1.1	0.58	1.04	1	0.76	0.38	0.68	0.86	1.04
5–Na Chlumu	1.68	0.64	1.02	1.36	1.28	1.3	0.78	1.26	1.08
6–Alkazar	1.78	0.76	1	1.44	1.26	1.18	1.14	1.22	0.88
7–Velká Amerika	1.76	0.44	1.26	1.58	1.64	1.6	1.34	1.34	1.12
8–Malá Amerika	1.5	0.24	1.36	1.6	1.4	1.46	1.12	1.38	1.16

Statistically significant results with $p \leq .05$.

By disaggregating participants' sense of place bundles, we demonstrate that different predictors have different effects on different sense of place components. This finding shows the dynamic nature of the sense of place and that it is possible to identify and potentially predict its composition. Our approach also allows the transferability of the sense of place as previously discussed by Svobodova et al. (2021), meaning the sense of place bundles can be re-established in another place. The multi-dimensional structure of our sense of place is similar to those identified by other authors such as Counted (2016), Scannell and Gifford (2010) and Raymond et al. (2010).

Our findings further show that it is possible to identify what sense of place components were more important in the bundles than others, in the sense that some components created more statistically significant interactions with predictors. We found that the quarry features on average participated in 5.5 significant interactions with predictors (a total of 22), whereas feelings were on average in 3.6 (a total of 39) and activities in 3.0 (a total of 12).

The atmosphere, unique flora and fauna and nature and geology were the most common quarry features in the participants' sense of place bundles, creating the strongest links to the predictors of participants' experience and preferences and to the quarry predictor. The important role of knowledge and direct experience of participants in the Czech Karst in their valuation of quarry features was evident in our results. With increasing knowledge, frequency, and history of

visiting the area, the participants reported these features more often. Conversely, Kaltenborn and Williams (2002) found that residence and experience of use history had limited effects on the attachment among both locals and tourists.

Joy and relaxation were the most common feelings expressed by the participants, interlinked with a total of 11 predictors—mainly with participants' experience and preferences and the quarry predictor. Their importance in the concept of sense of place has already been supported by several studies such as Hernández et al. (2020) and Kyle et al. (2004). In the study by Scannell and Gifford (2017), who measured experienced psychological benefits of place attachment, relaxation and joy were among the most commonly experienced feelings. Relaxation was even identified by 49% of the study participants and other positive emotions such as happiness, joy, hope and pride by 38% of the participants. Overall, in our study, we found prevailing positive effects of the sense of place predictors on participants' feelings. It indicates the functioning of the sense of place as a driver of place re-making toward beneficial psychological outcomes.

In terms of participants' activities, geocaching was the activity most often reported, equally interacting with predictors from all three groups. The typical participant who reported geocaching as the target activity in the quarries was young, student with a low or no previous experience in the area. This is in line with studies by Cord et al. (2015), who found that geocachers were younger than the average population, and Telaar et al. (2014), who showed that geocachers find experiencing nature and exploring new places as the most important motivation for the activity.

Among the sense of place predictors, the quarry was the strongest one, interacting with a total of 16 out of 19 sense of place components across all three groups. In our study, the quarry predictor symbolizes the physical aspects of the places. In this way, Shields (1991) argues that the nature of the physical place strongly affects the sense of place and place making. The importance of the physical environment in people's sense of place was also highlighted by Ghoomi et al. (2015). On the other hand, Stedman (2003) suggested that individuals are not directly driven in their sense of place by the physical features of a place, but rather through symbolic meanings that those features represent. In terms of the disruptive aspects of the quarry predictor, Svobodova et al. (2021) identified place attachments in heavily industrialized places such as coal mines and tailings. In another study, Svobodova et al. (2012) demonstrated that mining landscape features are associated with esthetic values.

Predictors of participants' experience and preferences were found on average in 6.8 significant interactions with the sense of place components (a total of 41). The predictor of quarry perception, measuring how much participants perceived quarries as typical features of the Czech Karst, was the most common in the bundles from this group of predictors, positively interacting with 10 feelings components and 2 quarry features components. In our conceptualization, participants' experience and preferences indicate the time and knowledge dimensions of place re-making after quarrying. Reflecting on Jackson (1994) p. 151 who believes that "a sense of place is something that we ourselves create in the course of time. It is the result of habit or custom," our results show that with increasing direct experience and knowledge of the disrupted place and increasing time span from the disruption the connection to the place becomes stronger. This was apparent in the overall positive feelings about the seven already restored quarries, the higher number of various activities related to these quarries and the higher number of features of these quarries that people found valuable.

Participants' socio-demographic characteristics were present in 3.2 interactions on average (16 in total), with the region and occupation as predictors involved in most of the interactions across the bundles. Our findings showed that participants with a home region close to the study area (grouped as locals) reported stronger sense of place than others. This is in accordance with Brown et al. (2015) who argue that the sense of place is a spatial subset of one's cognitive "values home range" representing a cognitive map of human space and recommend using distance-based rather than area-based measures in its mapping.

The significance of social-ecological restoration in peoples' place re-making processes was apparent across all our findings. We analyzed seven ecologically restored quarries and one operating quarry. Čertovy Schody, the only active quarry in the study, received the lowest ratings for most of the feelings and as the only quarry was associated with negative feelings (unsafe, unromantic, low benefits for nature and communities). The participants rarely reported this quarry as valuable for its nature and geology, flora and fauna and atmosphere—as they did with the other already restored quarries. On the other hand, Čertovy Schody was valued for its cultural and industrial features, which links to the studies by Beranová et al. (2017) and Petersen (2002) where quarries were appreciated as objects for geotourism and geoscientific education.

6 | CONCLUSIONS

The global pressure to deliver materials for construction resulting from urbanization poses considerable sustainability challenges. The construction boom supporting the growing urban population is disrupting the sustainable development of many regions worldwide and will continue to do so in the future. Quarrying regions in particular face pressures to ramp up mineral extraction and adapt to new development modalities. In these regions, the ability and motivation of people to re-establish their interactions with places affected by mineral excavation are central to the global sustainability agenda.

Sustainable development is a context-dependent and place-based concept where sustainability policies materialize locally. We argue that notions of sense of place and place (re)making should be key themes of the current sustainable development debate. By focusing on sense of place and place (re)making, the debate can encourage the creation of emotionally and socially sustainable communities, fostering a sense of connection and belonging among residents. Our approach provides a conceptual basis for understanding the processes by which people iteratively recreate their connections to places shaped by long-lasting disruptions, such as mining and quarrying, that

erased prior socio-cultural and material landscapes. This type of conceptual thinking is pivotal to achieving the policy outcomes required in the global sustainable development arena to avoid "ghost places" scenarios following these types of disruptions.

In our research, we emphasize sense of place as a key element and driver of place (re)making processes. We argue that sense of place is formed in bundles where predictors and components interact in a dynamic system. This conceptualization allows for the content of the bundles to be analyzed, modified, transferred, and changed over time. By focusing on three components of sense of place (feelings, activities, and features), we move beyond a normative view of sense of place as an idealized positive construct for sustainability outcomes. We show that although values and cognitions are subjectively held and vary among participants and places, this variation can be organized and measured. Analyzing the content of the bundles may provide insights into critical questions of the sustainability challenges in terms of matching individual and collective place-based interactions with regional sustainable development goals. These insights may help to better understand the human variables that constrain or enable just development.

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