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NEWLY DISCOVERED MASSIVE GLACIAL BOULDER IN NORTHWESTERN POLAND: IMPLICATIONS AND PROSPECTS FOR SUSTAINABLE REGIONAL GROWTH

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Abstract: The aim is to recognise the importance and role of geodiscovery as part of a wider sustainable local development strategy to benefit residents and tourists alike. The research was conducted on a massive erratic boulder discovered in February 2024, in NW Poland. The study included the collection of data on dimensions, petrographic type, erratic boulder type and specific microforms indicating the influence of morphogenetic processes from subglacial, periglacial and modern environments on the erratic boulder. The Jarosik Boulder in northwest Poland is crucial for advancing earth sciences, ecological awareness, and regional economic development. Residents of Grabowo and Kamień Pomorski value and monitor the area's geo-diversity to anticipate environmental changes. The boulder has a strong emotional connection with locals, who actively engage in its preservation and online discussions. Promoting the boulder can enhance the region's environment, culture, and well-being, contributing to sustainable development. Local initiatives and effective promotion through media and community events are essential for boosting geotourism and benefiting both residents and visitors. Recognised as a cultural asset, Jarosik Boulder can realise its full potential through the commitment of local authorities to improving the community. As a unique aspect of geodiversity in NW Poland, Jarosik Boulder serves as a catalyst to promote geological science, support environmental education efforts, and foster sustainable economic and regional development.

Keywords: geoheritage, Scandinavian erratic boulders, geoecosystem services, sustainable development, geotourism, north-west Poland

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INTRODUCTION

Geodiversity is often easily accessible, yet there are occasions when it is only recently unearthed. Geological heritage, as described in (Carrión Mero et al., 2018), encompasses geological features or sites (geosites) of exceptional scientific, cultural, and educational significance. As stated in (Urban et al., 2021), geological heritage includes non-living elements of nature, such as fragments of the Earth's crust, its topography, and the dynamic processes shaping the planet. These elements enable scientific exploration of Earth's history, life evolution, and understanding of the forces shaping the planet, while also holding cultural and intellectual value for society. They play a vital role in maintaining the benefits of the geosystem, supporting sustainable human existence within the ecological balance of a changing environment.

Among these elements are large erratic boulders, defined in (Górska-Zabielska et al., 2019) as rock fragments originating from the Baltic Shield and the bed of the Baltic Sea, transported and deposited by ice sheets during Pleistocene glaciations. These fragments encompass various petrographic rock types, including igneous, metamorphic, and sedimentary rocks, with sedimentary rocks being particularly rare in the boulder fraction. According to literature cited in (Górska-Zabielska et al., 2022), the shortest axis of an erratic boulder should measure at least 0.5 meters. Certain erratics, termed indicator erratics, have been identified as having only one outcrop of relatively small size in their parent occurrence area (e.g., Scandinavia; Figure 1), as described in (Lüttig, 1958; Czubla et al., 2006; Meyer and Lüttig, 2007).

Existing glacial boulders are found in situ in forests (Górska-Zabielska, 2022) and cemeteries (Głaz Trygław), and ex situ in parks (Woźniak et al., 2015), lapidaries (Meyer, 1981, 2006; Górska-Zabielska and Dobracki, 2015; Keiter, 2017; Górska-Zabielska, 2023a, b), and gardens (urban (Górska-Zabielska, 2013) and private (Górska-Zabielska et al., 2022)). They are legally protected (Górska-Zabielska, 2023b; Górska-Zabielska et al., 2022). However, the discovery of new, especially large erratic boulders seldom reaches the public and researchers due to a lack of ecological awareness among discoverers (Górska-Zabielska, 2017a). Consequently, the potential significance of newly discovered erratic boulders for securing geosystem services to the environment is rarely documented in literature.

Unfortunately, when the owner of an erratic boulder is unsure of how to incorporate such a geological discovery into their future plans, they often resort to selling it for practical purposes like cemetery slabs or home construction materials (Piotrowski, 2008; Chrząszczewski, 2009; Górska-Zabielska, 2017b). Consequently, it becomes challenging to find literature discussing the significance of newly found erratic boulders in providing geosystem services to the environment.

However, in cases where the explorer or owner prioritizes environmental sustainability, efforts are made to excavate these obstacles from bedrock sediments and relocate them to safer locations. For instance, Jędrek from Wilkowyja (Górska-

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Zabielska, 2023b) now stands in front of the local primary school. Similarly, a boulder from the center of Warsaw was moved to Pole Mokotowskie Park for aesthetic reasons. Occasionally, however, erratic boulders remain in place due to their sheer size. In such instances, considerations are made regarding their use in their current location, as seen with an unnamed boulder in Żochy (Górska-Zabielska, 2023b). This article presents a similar scenario.

In the context of geoecosystem services theory (da Silva and do Nascimento, 2020; Hekrle et al., 2023; Arias-Díaz et al., 2023; Zhang et al., 2023), erratic boulders offer intangible cultural benefits. Historically, the largest ones held spiritual and religious significance, like the Triglav Boulder and St. Adalbert's Boulder (Górska-Zabielska, 2020). Smaller boulders were often associated with religious symbols, such as the feet of the Virgin Mary and other saints (Miechowicz, 2010).

Today, erratic boulders primarily serve educational purposes in domestic tourism. However, they also play cognitive, educational, pro-environmental, geoethical, geoenvironmental, cultural, protective, recreational, aesthetic, sentimental, and supportive roles in the sustainable development of regions. These diverse functions of erratic boulders are leveraged in geotourism, promoting geosciences and geodiversity conservation (Dowling, 2010; Górska-Zabielska, 2020, 2023b; Górska-Zabielska et al., 2020; Elmi et al., 2020; Frey, 2021; Drinia et al., 2022).

METHODOLOGICAL ASPECTS: OBJECTIVES AND RESEARCH METHODS

Considering these contributions, this article has two main objectives: to announce the remarkable discovery of a large erratic boulder in northwest Poland and to showcase how the country's abiotic heritage is managed sustainably by dedicated institutions. Additionally, it aims to highlight the benefits provided by the geoobject to the geosystem (Van Ree and Van Beukering, 2016): cognitive, educational, pro-environmental, recreational, and aesthetic. The additional objectives involve increasing understanding of the geological history of the area among local residents, nurturing a connection to the land (Koupatsiaris and Drinia, 2024), bringing attention to the importance of preserving natural resources, fostering positive attitudes toward the environment, and instilling ethical values related to the Earth's systems (Georgousis et al., 2021).

If the massive glacial boulder were to be relocated to the heart of an adjacent town Kamień Pomorski, it has the potential to establish an innovative space for education and recreation, equipped with amenities for tourists. This facility could serve as a valuable resource for geography educators to conduct outdoor lessons, enhancing the visual appeal in line with the surrounding environment (similar to the concept of pocket gardens, e.g., Jasprizza, 1999). It could also cater to recreational activities like walking and cycling, while offering psychological and physical benefits to visitors (Gesler, 1993; Davern et al., 2016; Williams, 2017), ultimately contributing to sustainable development at the urban and regional levels (Frey, 2021; Górska-Zabielska, 2023a; Ehsan et al., 2012; Reynard et al., 2017; Suzuki and Takagi, 2018).

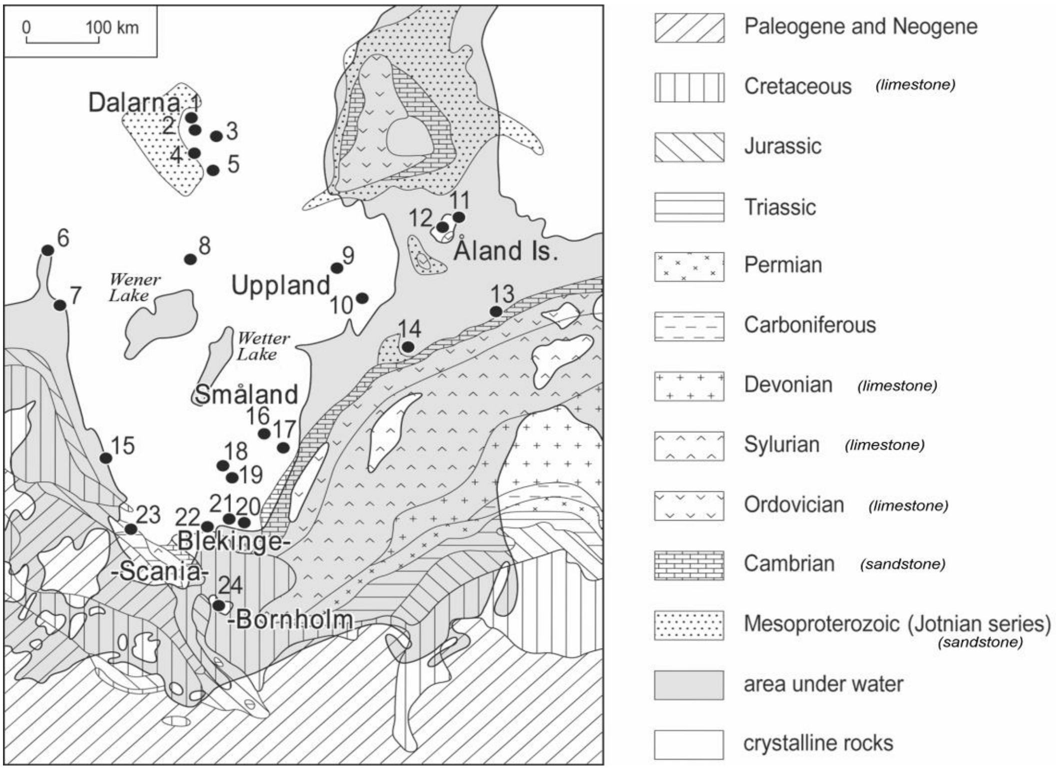

Figure 1. Locations of outcrops of crystalline and sedimentary rocks, the parent areas of erratics from glacial deposits of the European lowlands, are indicated (based on Bingen and van Breemen, 1998 and Górska-Zabielska, 2020). Lithology is given only for those chronostratigraphic units whose erratic boulders and gravels are present in Poland. No. 19 corresponds to the outcrop of Växjö red granite in the Småland region of southeastern Sweden, which serves as the alimentation region of the Jarosik Boulder (JB)

Through this article, the author emphasizes the social role of science, aligning with the university's mission to address the needs of smart city residents and collaborate with local governments for the benefit of the community (Albino et al., 2015; Budziewicz-Guźlecka, 2017; Bifulco and Tregua, 2018; Hajduk, 2020; Kardasz, 2023). Field research methods exclusively were employed for the erratic boulder. During the survey, the length, width, and height of the boulder were measured. The estimated volume of the boulder was then calculated using the formula of Schulz (1964): 0.523 × length × width × height, and the weight of the boulder was determined, assuming that 1 m^3 = 2.75 tons. Attention was given to the petrographic type and the erratic kind (as per Lüttig, 1958; Czubla et al., 2006; Meyer and Lüttig, 2007). Indicator erratics are significant due to their uniqueness - they have only one outcrop in the bedrock of the Scandinavian peninsula (Figure 1). This enables pinpointing their source areas and determining the direction of the main glacial transport.

Any microforms on the surface of the boulder were also examined with interest, as they provide an indisputable record of the processes that interacted with the boulder both in the parent area, during transport within the ice sheet, and after melting in the periglacial environment in the foreland of the shrinking ice sheet. Microforms recorded on the surface of the erratic boulder, such as joint-bounded crescentic scars and glacial polish, have been studied. They were formed by subglacial clast-bed contact forces and serve as evidence for bedrock failure beneath the ice sheet (Krabbendam et al., 2017). Their formation is characteristic of a subglacial environment, wherein a boulder transported at the base of an ice sheet rubs against a substrate harder than the boulder itself. The condition of the corners, indicating their reworking, which is evidence of transport in high-energy subglacial and inglacial tunnels, was also examined. The characteristic micromorphological features recorded on the surface of the boulder in the periglacial environment (e.g., eolian corrasion marks, ventifacts, eoglyptolithes) were also documented. The influence of contemporary morphogenetic processes (e.g., exfoliation, corrasion, colonization by epilithic flora) on the surface of the boulder (Górska-Zabielska, 2022, 2023a; Woźniak et al., 2015; Górska-Zabielska et al., 2020; Górska-Zabielska and Zabielski, 2018) was also the subject of field analysis. The author captured the photographs on March 9th, 2024.

STUDY AREA

The erratic boulder is situated in northwestern Poland, specifically in the village of Grabowo within the coastal district of Kamień Pomorski (Figure 2), approximately 5 km south of the Baltic Sea coast. Presently, it rests in a cultivated field, embedded in clayey sediments of the subsoil. Its depth, around 0.5 meters below the surface, indicates its position within the most recent sediments deposited by the last Scandinavian ice sheet in the region. The boulder is believed to have been left behind during the concluding stages of the Pomeranian phase (with a maximum range of 15.2 14C ka (Kozarski, 1986, 1988; Marks et al., 2016), 16.2 ka BP (Kozarski, 1995), 14.8±0.4 10Be ka (Rinterknecht et al., 2005) of the Vistula glaciation (MIS 2), possibly during the Rosenthal (- Szczecin) Staffel subphase (Brose, 1978; Schroeder, 1994). This occurred prior to the advancement of the last ice sheet onto Polish territory during the Gardno subphase (circa 14 BP, (Mojski, 2005), between Darłowo and Lake Gardno (Figure 2).

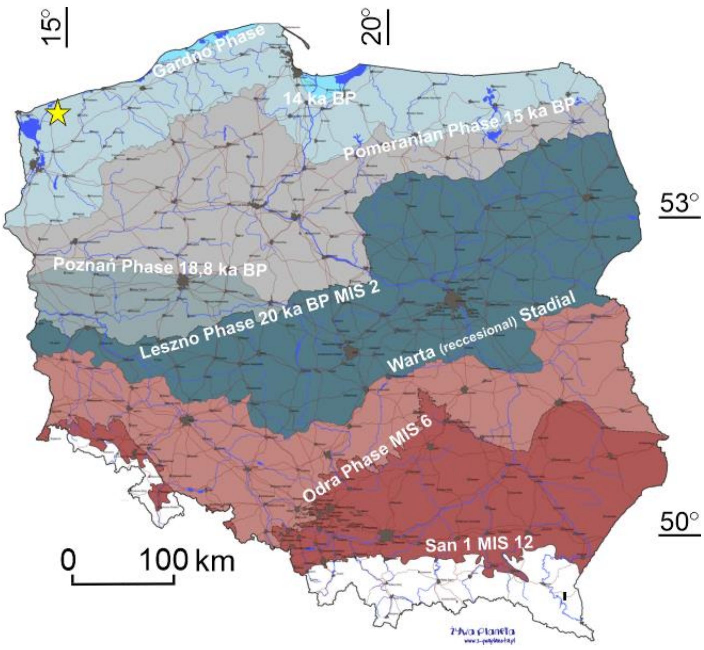

Figure 2. Map depicting the extent of Pleistocene (Scandinavian) glaciations in Poland. Only the most significant glaciations, stages, and phases are depicted. An asterisk indicates the location of the Jarosik Boulder (JB) (Source: Adapted from: https://zywaplaneta.pl/zlodowacenia-plejstocenskie-w-polsce/, changed)

The landowners in the area are committed to environmental education and to raising the awareness of the local population about the state of their environment. Agreement, cooperation, awareness of the sense of place (Koupatsiaris and Drinia, 2024) and the importance of discovery, as well as sensitivity to the beauty of the inanimate nature of the owner of the field, Mr Robert Jarosik, the parish priest of the Kamień Pomorski Cathedral of St John the Baptist, Dariusz Żarkowski, and the Director of the Museum of the History of the Kamień Pomorski Lands, Grzegorz Kurek, MA, resulted in fieldwork being carried out just one month after the object was unearthed (in February 2024) to investigate the exceptional size of the erratic boulder. This article describes it in detail.

CHARACTERISTICS OF THE JAROSIK (ERRATIC) BOULDER (JB)

The erratic boulder is situated in situ, meaning it remains at the original site of its glacial deposition (coordinates: 53°59'00.3"N 14°48'48.9"E; https://maps.app.goo.gl/W1xkep5kEJiearYXA). Currently, accessing the boulder is challenging due to it being covered by a layer of arable soil. The measured dimensions of its visible portion were as follows: length 470 cm, width 390 cm, height 140 cm, perimeter 1212 cm. Calculations yield a volume of 13.42 m³ and a weight of 36.91 tons. Petrographically, it consists of granite, an igneous rock, characterized by Zandstra (1988): "... Medium-grained, red-grey, pale red or grey-pink; quartz partly granulated, partly as independent grains; feldspar (mostly microclinperthite) up to 1-2 cm, partly finely crushed, grey-red; plagioclase mostly inconspicuous; dark minerals grouped; colour of the quartz grey-white to colourless (if granulated) as well as bluish or violet-blue (the independent grains); all minerals show very irregular grain boundaries …" These features point to Växjö red granite (No. 19 in Figure 1), an indicator erratic, originating from the Småland region in southeastern Sweden. Its source area was situated on the Baltic Shield, which constitutes a portion of the Eastern European Platform (Figure 3).

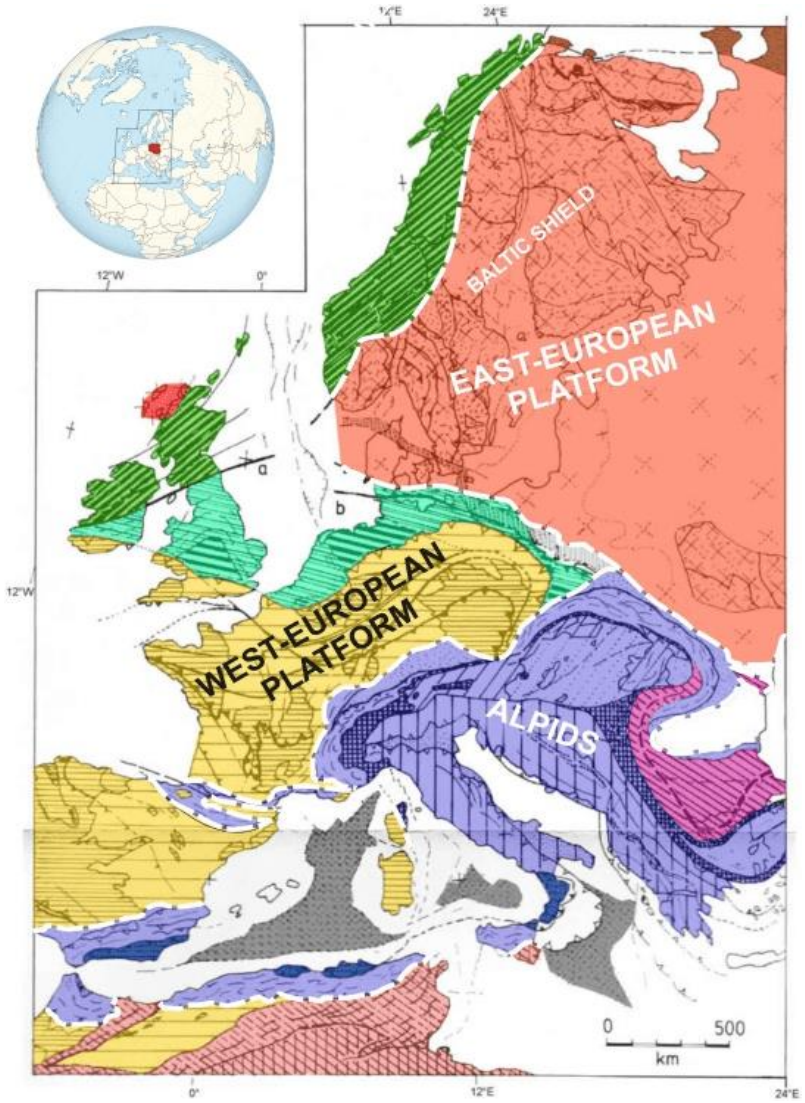

Figure 3. Schematic tectonic map of Europe depicting the location of Poland
and an enlarged area in the upper left corner (Source: Adapted from Artemieva et al, 2006)

Before arriving at its current state, however, the northern Europe had a long history of formation dating back to the Archaic era. The crystalline formations of Fennoscandia were shaped by five diastrophic cycles, ultimately leading to orogenesis. Among the most significant orogenies in the region that supplied igneous material to the European lowlands were the Svekophene or Svekofeno-Karelian orogeny (1.96-1.75 billion years; Korja and Heikkinen, 2005), the Gothic or Dano-Polish orogeny (1.5-1.42 billion years; Bogdanova, 2001)), and the Svekonorwegian orogeny (1.14-0.9 billion years; e.g., Bingen and van Breemen, 1998). During these events, liquid magma began to solidify, crystallize, and stabilize amidst landform movements, contributing to the formation of the Baltic Shield (Figure 3).

Throughout this protracted process, the Baltic Shield was repeatedly subjected to tectonic movements accompanying the orogeny, resulting in fractures and fissures in the rocks. These fractures, known as massif thrusts, play a crucial role in determining the size of erratics. Consequently, the fewer fractures present in the crystalline substrate of Scandinavia, the larger the dimensions of the erratics in the glacial depositional area.

Figure 4. The Jarosik Boulder, Växjö red granite from Småland, SE Sweden, is of great interest to local people

This phenomenon elucidates the substantial dimensions of the JB (Figure 4). Another notable feature is a narrow depression on the vertical north face of the erratic boulder, extending along its entire length (No. 3 in Figure 5). This depression is believed to be a narrow fissure formed during the solidification of magma under altered temperature and pressure conditions. Today, it represents a weakened surface more susceptible to erosion.

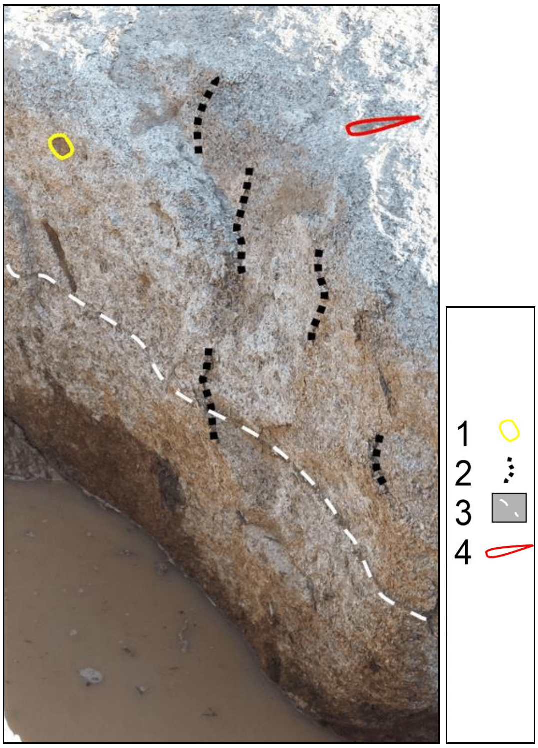

Figure 5. Explanation of the signatures: ① on the northern face of the boulder: 1 - natural tafoni, i.e. a cavity after selective weathering of the rock, 2 - exfoliation front, 3 - detachment surface, formed during magma crystallisation; ② on the upper face: 4 - cavities after a deliberate blow to break the lump into smaller fragments

The Archean land-forming stage, characterized by magma solidification and tectonic movement, is evidenced by a 3-5 cm narrow vein (Figure 6) traversing the entire boulder. This vein formed when magma infiltrated a narrow crack during the fracturing of pre-existing rock. It is clearly visible on the upper surface of the JB.

The subsequent stage in the boulder's evolution, inferred from microforms observed on its surface, involves the erosion and smoothing of its present upper surface (Figure 6). This smoothing likely resulted from subglacial abrasion in the maintenance/source area in southeastern Sweden. The grinding could have occurred while the rock was still anchored in bedrock, with the heavily stony ice sheet moving over it, or after the block detached and was positioned at the base of the moving ice sheet, rubbing against hard, crystalline bedrock. Evidence of surface removal includes preserved smoothness (a flat surface) and barely discernible glacial scratches (glacial striae) on the eastern part of the upper surface of the JB (Figure 7). Their location on the upper surface indicates that the boulder is now "upside down" compared to its orientation when it was dragged at the base of the ice sheet. The scratches are visible at the appropriate viewing angle and under sunlight.

Figure 6. A narrow vein runs through the entire lump of erratic rock; note the relatively flat top surface and the rounded corners and edges of the erratic rock

Figure 7. A series of glacial striae with a NNE-SSW orientation that record subglacial processes from the period when the JB was still in the maintenance area in SE Sweden

Rarely sealed, weathered crystalline basement in southeast Sweden facilitated the incorporation of a large ground fragment into the moving ice mass, under favorable rheological conditions. Identification of the erratic, based on the structure and texture of the rock, suggests incorporation occurred in the Småland region. An erratic originating from a specific outcrop in Scandinavia is referred to as an indicator erratic. Its presence in the glacial deposition area is significant because it is unique, originating from only one outcrop on the Scandinavian peninsula (Figure 1), indicating its source area and indirectly the migration route of the ice sheet. During transport from the Småland region to the final depositional site near Grabowo, the rock underwent corner and edge processing, now evident in its typical rounding and curvature (Figure 6). This indicates transport in high-energy subglacial and englacial tunnels of the ice sheet. In 1875, Swedish geologist Otto Torell confirmed the glacial transport of erratic boulders. Since its glacial deposition between 15 and 14 ka BP, the boulder has remained undisturbed by humans, likely due to its large size. However, these dimensions have prompted attempts to utilize the rock for functional purposes. Evidence of anthropogenic destruction includes small, sharp-edged depressions (5 x 3 cm with a sharp point on one side; Figure 5), equally spaced in a line about 15 cm from the north edge of the boulder. These may indicate an unsuccessful attempt to extract a flat rock fragment for purposes such as cemetery masonry or other construction. The exact timing and perpetrator of this irreversible surface damage are unknown. However, it is evident that much of the boulder was previously above ground level, explaining the interest in its practical use.

Natural climate changes led to the shrinkage and melting of the ice sheet, releasing the mineral load it carried from Scandinavia's feeding areas. At the end of the Pomeranian phase, the JB melted out. Subsequently, under periglacial climate conditions, rock degradation began due to atmospheric factors such as water, temperature, wind, and later, likely epilithic flora. This resulted in modern morphogenetic processes affecting the boulder's surface, evidenced by:

- Intense physical weathering affects both the upper flat surface and the lateral surfaces of the rock, such as the northern one (Figure 5), resulting in numerous pits, micro-niches, depressions, also known as tafoni, formed after the weathered minerals have eroded away.
- Chemical weathering, through chemical reactions of aluminosilicates, particularly feldspars, results in the formation of kaolinite. Water presence is a necessary condition for feldspar decomposition, and the weathering process is further facilitated

by the presence of epilithic flora colonizing the rock's surface. Chemical weathering is induced by humic acids dissolved in the surface layer of the rock. However, the epilithic flora, unable to survive, perished after the rock was buried in soil sediments.

- Corrosion microforms appear as elongated micro-depressions, resulting from the loss of weathered minerals in one direction. Presently, they manifest as short, parallel furrows over a large area, formed by the grinding of the surface by quartz material from outwash deposits on the forefield of the ice sheet in unidirectional wind currents, indicating stable weather conditions.
- Corrosion processes alter the boulder's shape relatively quickly, with the typical ridge unable to develop fully. Instead, corrosion processes are evident in the form of aeolization of the rock block's surface.
- Widespread exfoliation, or flaking, of the near-surface rock layer occurs as a result of water circulation in microspaces and its chemical and physical action, including ice, on this part of the erratic boulder. All these microforms, products of modern morphogenetic processes sculpting the rock's surface, obscure postglacial features, with pits and furrows overlaying narrow, long, and parallel micro-fissures formed during the subglacial stage of the rock's history. While scratches are barely legible today, they remain visible, at least to the trained eye (Figure 7).

THE SIGNIFICANCE OF THE JB - DISCUSSION

The erratic boulder near Grabowo forms an integral part of the region's geological heritage, contributing significantly to its geodiversity. Geodiversity refers to the varied and delicate state of the non-living environment, which, once disrupted, is challenging, if not impossible, to restore on a human scale. Geodiversity encompasses a wide range of genetically diverse abiotic resources within a limited area (Zwoliński, 2004; Serrano and Ruiz-Flaño, 2007; Gray, 2013, 2018; Ng, 2022). In the immediate vicinity of Grabowo, this includes:

- glacial features such as a flat-bottomed moraine formed by glacial clay deposited by the retreating ice sheet between 15 and 14 thousand years ago. Over time, this has transformed into fertile brown soil,
- numerous large Scandinavian erratic boulders, including the Royal Boulder on Chrząszczewska Island, which is legally protected as an inanimate natural monument under the Nature Conservation Act of 2004,
- the excavated JB significantly enriches the region's geodiversity,
- fluvial features formed after the retreat of the Pomeranian ice sheet, including ice-marginal valleys, meandering rivers, and paleomeanders,
- fluvial features interwoven with littoral features such as rivers, lagoons, bays, and islands.

The JB remaining in its original location, along with other elements of the abiotic environment, holds scientific significance. It provides valuable evidence of past geomorphological processes in the north-western parts of Poland during specific glacial phases. Additionally, its unchanged position since deposition makes it a crucial element in statistical analyses to determine ice sheet transport directions and date deglaciation using cosmogenic isotopes like ^{10}Be (Rinterknecht et al., 2005, 2012; Ivy-Ochs and Kober, 2008; Tylmann et al., 2017, 2019).

The JB has already sparked considerable interest among local residents, who have visited it during recreational walks, taken photographs, and engaged in discussions about its history and significance. News of the discovery has spread through local online press and social media platforms, transforming the boulder into a cognitive and scenic landmark. Nevertheless, the utilisation of storytelling is essential in order to convey the advanced interpretation necessary to gain insight into geological processes of the find in a manner that is both professional and engaging, thus captivating the audience. The educational role of JB is of great value.

Considering the importance of the discovery and the municipality's sustainable development strategy, the local council is likely to establish the boulder as a natural monument, providing legal protection under the Nature Protection Act of 2004.

Although the owner of the field, Mr. Robert Jarosik, had to bury the JB temporarily for field work, its presence remains embedded in the local community's consciousness. Erecting an informative board detailing essential information about the geoobject is proposed, following exemplary models (Kicińska-Świderska and Słomka, 2004; Stolz and Megerle, 2022). Furthermore, protecting the board from vandalism is suggested, possibly through suitable coatings. The design, production, and installation of the board should be entrusted to local entrepreneurs to create new job opportunities and support the region's sustainable development efforts.

If local and regional authorities decide to relocate the JB to a more prominent location, such as the centre of Kamień Pomorski, its primary scientific value would diminish as it moves from its original position due to human intervention.

However, this relocation would bring about the following changes and functions:

- **Educational:** Equipped with informational displays and guided tours, the boulder could serve as an educational resource. This could facilitate learning across various subjects such as geography (e.g., petrographic types of rocks and ice sheet activity), art (drawing outdoors), mathematics (teaching measurements and calculations of the volume and weight of a boulder), chemistry (showing the types of minerals and teaching their chemical formula), and languages (writing an essay/poem about the need to protect nature), fostering a deeper understanding of nature and inspiring creativity and conservation efforts. The educational function of erratic boulders has already been used by (Meyer, 1981, 2006; Górska-Zabielska, 2023a, b). Many papers explore the educational roles of geoheritage (Mamoon, 2014; Tormey, 2019; Drinia et al., 2023; Zgłobicki et al., 2024), but only few specifically address Scandinavian boulders.
- **Geoethical:** By fostering a sense of connection to the local environment (sense of place), the boulder could encourage more responsible behavior and promote sustainable development practices. The author has discussed this function of erratic boulders (Górska-Zabielska, 2021, 2023a, b), and while numerous papers examine the geo-ethical significance of geoheritage (Peppoloni and Di Capua, 2012, 2016; Mansur et al., 2017; Koupatsiaris and Drinia, 2024), few have specifically focused on Scandinavian boulders up to this point.

- **Geoenvironmental:** The boulder provides ecosystem benefits to both humans and nature. It offers cultural services by fulfilling the need for knowledge and education, while also supporting ecological balance by providing nutrients to the soil and regulating bio-nature. As far as the author knows, there are no published papers on this topic related to Scandinavian glacial boulders; however, some texts are currently in progress.
- **Cultural:** The cultural significance of the boulder lies in its role as a testament to anthropogenic activities, evidenced by small yet numerous traces of attempts to break it into smaller pieces. Another illustration of such a cultural aspect of Scandinavian boulders is exemplified by the Markgrafenstein, Germany's largest on-land erratic, located in Brandenburg, 40 km southeast of Berlin. The Karlshamn (an indicator erratic from the Blekinge region in south Sweden) Markgrafenstein was toppled in 1827 and transported to Berlin, where it now forms a large bowl in front of the Altes Museum in the Lustgarten (Schulz, 1964; Gohlke, 1996; Göllnitz, 2003; Schroeder, 2006; Baumann et al., 2004). However, it's important to note that the cultural heritage associated with glacial erratics can also have positive connotations, which unfortunately isn't the case with JB. Sometimes, these erratics are linked to various legends, with local communities regarding them as sacred objects. This is particularly common for those with distinct markings or signs believed to confirm their supernatural powers. Miechowicz (e.g., 2010) categorizes them into two groups: stones with traces of the so-called 'feet of God'—which according to legends, indicate the presence of figures like the Virgin Mary, Jesus, or certain saints—and stones with 'bowls' believed to possess healing properties from the water collected within them. Many of these legends are rooted in Christian tradition and the widespread belief in miracles purported to have occurred in their vicinity (Górska-Zabielska, 2024), www.bozestopki.edu.pl).
- **Pro-environmental, Educational:** By raising awareness about the value of nature and encouraging its preservation, the boulder can foster a pro-environmental ethos. Through education and awareness, communities can make informed decisions about the legal protection and conservation of geological landmarks. This issue was addressed by, for example, (Meyer, 1981, 2006; Górska-Zabielska, 2021, 2023a, b; Górska-Zabielska and Dobracki, 2015; Keiter, 2017; Bartholomäus, 2001; Brügmann, 2003; Dietrich and Hoffmann, 2003; Hanácek et al., 2007).
- **Conservation:** Legal protection under the Nature Conservation Act of 2004 would safeguard the boulder's cultural and ecological significance. Previous efforts by individuals (Szarzyńska, 2015; Czernicka-Chodkowska, 1980, 1983; Urban, 1990) and organizations have contributed to the conservation of erratic boulders in Poland, indicating growing recognition of their importance.
- **Aesthetic:** Placing the JB in a prominent location, like in a pocket garden (Jasprizza, 1999; Collins, 2020), could enhance its visual appeal and contribute to the beauty of the surrounding area. Such initiatives often receive positive feedback from residents and tourists, contributing to community pride and tourism promotion. Large erratics frequently remain in city centres, yet their geosystem services are rarely documented in scientific literature. Instead, these boulders are typically discussed in local guidebooks or leaflets, particularly if they are associated with legends, as exemplified in (Harms, 1980; Hoffmann et al., 2003).
- **Sentimental:** Named after its discoverer, Robert Jarosik, the boulder serves as a reminder of local history and community involvement. Its sentimental value adds to its cultural significance and reinforces connections to the land and its people.
- **Improving Quality of Life:** The project to relocate and install the boulder with informative panels nearby would stimulate economic activity and provide employment opportunities for local entrepreneurs. Funds raised through initiatives like citizens' funds (Górska-Zabielska, 2023a) could further support sustainable development efforts.

These functions align with geotourism, an emerging sector in Poland that promotes the protection and promotion of geological heritage while contributing to sustainable development goals (Chylińska and Kołodziejczyk, 2018; Risteski, 2014). Geotourism harnesses natural assets to bolster local economies and foster community engagement (like providing employment in work related to the exposure and geo-interpretation of geoobjects), making it a valuable tool for regional development (Brilha et al., 2018).

CONCLUSION

The Jarosik Boulder, a remarkable geological feature in northwest Poland, serves as a catalyst for advancing earth sciences, fostering ecological awareness, and promoting regional economic development and sustainability.

The attentiveness and concern of residents from Grabowo and Kamień Pomorski towards the natural environment have led to an appreciation of the geodiversity in the area. Monitoring its changes helps anticipate environmental shifts and assess the suitability of natural conditions for various functions (Richling and Solon, 2011).

The JB has already captured the hearts of locals, who are committed to preserving this valuable relic from the Ice Age. Their interest is evident in discussions about the boulder and online engagement, demonstrating a strong connection to the geological history of their homeland and a sense of place.

Efforts should now focus on promoting and potentially showcasing the JB. Inanimate natural features contribute to the geographical character of a place, enriching its environment, culture, aesthetics, heritage, and the well-being of its inhabitants (National Geographic). Their role in sustainable development is vital, as responsible management of these resources enhances the region's image and respects principles of nature conservation.

The implementation of local initiatives, including the establishment of new hiking trails, orienteering, geocaching, nature-themed rallies and festivals, coupled with the introduction of outdoor lessons, is crucial for the advancement of nature awareness among the population and the promotion of geotourism. The effective promotion of activities, such as the dissemination of information about the Jarosik Boulder through local media channels, the distribution of QR code flyers and the organisation of community events, will optimise the potential benefits of such initiatives for both residents and visitors. All such activities are aligned with the region's sustainable development principles, as they will enhance the quality of life for the residents of Kamień Pomorski and the surrounding area.

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