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Increasing social Acceptance in the Management of Tailings Storage Facilities (TSF)

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Cover Photo

The cover photo shows a thermographic infrared image of the campus of the Georg Agricola University of Applied Sciences in Bochum in Germany. The picture was created by overlaying several hundred individual images taken as part of a drone photography flight (funded by the RAG Foundation). Here the sensor measures the radiometric radiation that is converted by modelling into temperature values and then georeferenced to the nearest centimetre using GNSS coordinates with real-time correction data. An evaluation is then undertaken on the basis of on-site temperature measurements and corrections are made with reference to air humidity and solar radiation along with links to optical and multispectral images from other unmanned flights.

Thermographic images play an important role in the environmental and geomonitoring of objects (technical installations) and land surfaces (post-mining processes affecting nature and the landscape). The results obtained from geomonitoring work lead to a deeper understanding of the processes involved. This extremely useful tool plays a vital role in providing a link between all the different fields under investigation at the Research Center of Post-Mining (FZN).

The four main research areas at the FZN are ‚**Eternity tasks and mine-water management**', ‚**Geomonitoring**', ‚**Material sciences**' and ‚**Reactivation and transition**'.

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Increasing social Acceptance in the Management of Tailings Storage Facilities (TSF)

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Ensuring social acceptance for mining projects, and especially when it comes to settling ponds for mine tailings, is a huge challenge. Modern geomonitoring integrates data obtained from orbiting satellites, from overflying aircraft and from the surface of the ground, as well as from below it, to create a transparent and space and time-referenced process understanding. Geomonitoring technology is therefore an important tool for risk management and communication over the course of the mining lifecycle.

Mining • Geotechnics • Tailings • Operator responsibility • Acceptance • Geomonitoring • Risk management

Introduction

Mining means primary production and the extraction of natural resources and so stands right at the beginning of the value chains. Given the predicted growth in the global population from the current 7.7 billion to something like 10 billion by the year 2050 we can assume a similar increase in the demand for raw materials [1]. However, technological progress and social changes will almost certainly alter the make-up of the raw-materials mix. Moreover, commodity consumers are becoming increasingly out of touch with the mining lifecycle (**Fig. 1**) and their understanding of the technical and scientific processes involved is waning.

At the same time the legislators and non-governmental organisations involved in the current process of social change are now re-thinking their approach to climate and Earth-system protection [2], while at the same time many societies are promoting and introducing circular-economy systems. All this is starting to overshadow the raw-materials extraction process, even though this remains just as important as before [3, 4]. Ongoing digitisation and the increasing social penetration of modern communication methods, such as social media, and the resulting in processes acceleration, are also factors to be considered.

The mental disconnect between raw-materials extraction and consumer behaviour, and the growing focus on climate and environmental protection, mean that our society now only tends to see the negative impact that mining has on man and the environment and has adopted a highly emotional response to it. It is therefore difficult for mining companies to communicate in a fact-based and effective manner and to ensure transparency for the operational decisions that they have to take.

Another problem that affects communication and discussion with the public is that because of its finite nature the exploitation of a deposit cannot be directly connected with the concept of sustainability. While this can succeed in conjunction with the fairly comprehensive extraction of the deposit and an environmentally compatible mining process, in reality, linking the United Nations Sustainable Development Goals with mining activities poses significant operational and communicative challenges for mining companies.

However, open and transparent social communication is essential for the acceptance of the mining industry with its location-based and long-term mode of operation and its significant demand for skilled workers of all kinds. For this to succeed, mine operators need to take account of, and react to, economic, ecological and social changes. This kind of approach is also adopted in the Science Policy Report of the Academia Brasileira de Ciencias and Leopoldina, and other partners, which in the wake of recent accidents, particularly at tailings storage facilities (such as the Brumadinho dam disaster in Brazil in 2019), are calling for a collective paradigm shift on the part of legislators, mining companies, the scientific community and the public [5].

Fig. 1: Representation of the mining lifecycle

SLO - a Social Licence to operate

The term 'social license to operate' relates to the new social awareness in respect of the mining industry. This concept developed about 20 years ago as part of the discussion on sustainability and reflects the reputation of a company and its social acceptance. It is to be defined from both an internal and an external perspective.

In actual fact Georg Agricola wrote about the social responsibility of industry operators hundreds of years ago in his authoritative text on the mining and metallurgical industry 'De re metallica' [6]. In his first book entitled 'Vom berg- und hüttenmännischen Beruf und seinem Nutzen (The Mining and Metallurgical Profession and its Uses)' Agricola examined arguments relating to critical public opinion. His analysis of mining-induced damage to the environment and the benefits that mining activities bring to society can be understood as the beginnings of risk management theory.

For a mining company operator responsibility from an internal point of view means the technical and legal operating licence covering the entire mining lifecycle. The company acquires this licence after going through a process that includes approvals, environmental impact studies, geomonitoring plans and risk management systems. From a business viewpoint securing and reinforcing operator responsibility creates a positive environment in which the company's strategy and its net value added can be put to good effect [7]. Companies that are socially accepted often succeed in achieving their sustainability goals. They are able to deal very proactively with all the economic, ecological and social consequences of their commercial operations and with the credibility of their business endeavours [8].

From the external perspective of the public and stakeholders it is all about the social operating licence. This perception is characterised by various facets, such as reliability, values, trust, communication, network building, transparency and the development of knowledge and understanding.

In terms of sustainability and the preservation of the natural living conditions, in the context of forces, forms and values, these two ways of looking at the concept of operator responsibility can be represented in two processes that have been fundamental to the mining industry (**Fig. 2**) [2]:

- **Process 1** (dotted red line in **Fig. 2**): Historically speaking the object of the earliest and simplest form of mining was to alleviate existential distress and preserve the basis of life.
- **Process 2** (black dashed line in **Fig. 2**): In a further development of the industry-dominated mining lifecycle all is based on a position of power and the planned entrepreneurial actions of the mining companies, which manifest themselves in the special characteristics of the mining industry, such as location factors, company history and corporate strategy.

Only with the incorporation of the modern concepts that underlie the social licence to operate do we see any real involvement of the affected parties. This leads to an improvement in natural living conditions and results in greater social sustainability (green line in **Fig. 2**).

The issues that surround the social acceptance of mining companies are based on the assumption that the general public (e.g. local residents) and stakeholders from the mining environment are increasingly included in the making of decisions that impact them directly [9]. Voluntary initiatives on the part of the mine operator that go beyond his statutory responsibilities are a key element when it comes to attaining social acceptance. Despite the high awareness of social acceptance within mining companies there is still no consensus on the means to be deployed and their effectiveness [9]. The success of a social acceptance drive therefore depends essentially on developing and maintaining sustainable relationships with the stakeholders, in other words taking a participatory approach. This tactic therefore represents a core element in the communication process.

The social licence to operate comprises the integration of the company into the surrounding structures [10]. A management tool or management strategy has now evolved from this that is essentially aimed at the stakeholders and the socio-political structures. Every company that in its local environment has an impact on social matters with a human and/or environmental factor, and consequently is under observation, ultimately requires this kind of strategy. These new game plans, backed-up as they are by digitisation and the methods of Industry 4.0, enable new corporate cultures. This leads to broad-based transparency, an almost unlimited access to information and inter-company cooperation of the kind that can be implemented both top-down and bottom-up within the group structure [11].

The ongoing debate about the social acceptance of companies and their actions is also being conducted from the perspective of sustainability [12]. Even the United Nations Organisation, with its 17 sustainable development goals (17 SDGs), has intensified and broadened the discussions surrounding the sustainable management of operational processes [13]. Economic ethics have meant that mining operators now also have to face up to these goals and enter into a discussion with

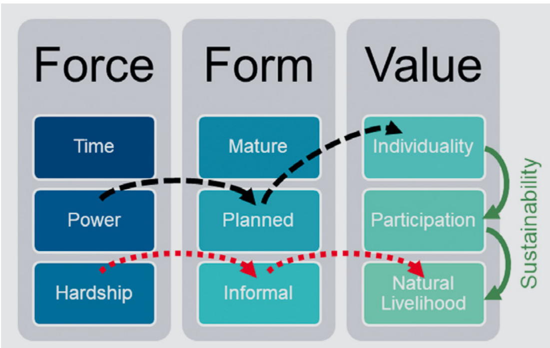

Fig. 2: Schematic depiction of the main interactions affecting mining processes in respect of forces, forms and values of relevance to sustainability [acc. to 2]

Fig. 3: Process stages in the environmental impact assessment showing the geomonitoring phases (direct involvement = red arrow, indirect involvement = light red arrow)

the public, with individuals and with the relevant stakeholders [1, 14].

Mining processes, such as the construction and operation of mineral preparation plants and tailings ponds, constitute an intrusion into the landscape and the natural environment and often cause irreversible changes. In this context the Geological Society of London, in its geoscientific interpretation of the 17 sustainable development goals, has laid down the following objectives for the mining industry and for tailings storage facilities [15]:

1 No poverty
2 Zero hunger
7 Affordable and clean energy
8 Decent work and economic growth
11 Sustainable cities and communities
12 Sustainable consumption and production
13 Measures to ensure climate protection

Since, as has already been mentioned, mining cannot strictly speaking be a sustainable operation because of the finite nature of any natural deposit, a conflict of objective can be seen to exist when it comes to the 12th sustainability goal. This conflict cannot be resolved on an abstract level, while remaining within the context of the sustainability goals, as is the case with the 12th of the UN targets. The environmental impact assessment (EIA) of mining activities and the sustainability factor, for example, can be taken into account right at the beginning of the approval process (**Fig. 3**) [16]. Important factors here are compliance with standards when it comes to operational, safety-relevant and communicative processes, a continuous analysis of the impact of the raw-material extraction operation and the limitation of negative effects. In addition, a participation process has to be established so that the regional population can be involved in terms of information and cost [5]. Here new opportunities can be provided in the form of integrated geomonitoring tools.

In this connection Pateiro Fernandez speaks about adopting a location-based approach for developing the sustainability paradigm, by which he means the specific reaction to existing framework conditions [17]. Here the aim is to minimise the negative impact on society and the environment while at the same time maximising the social and economic factors. The participation process, which is an integral part of the sustainability concept, will therefore serve to raise the level of social acceptance for mining-related measures.

Geomonitoring

Geomonitoring is a valuable scientific and technological tool for monitoring the lifecycle of a mining installation. In order to achieve the level of social acceptance referred-to above and to meet the risk-mitigation criteria it is important to develop and implement an integrated and continuous geomonitoring regime for mining operations (**Fig. 3**). A wide range of different methods can be adopted here depending on the issues being addressed (**Fig. 4**). The results of the geomonitor-

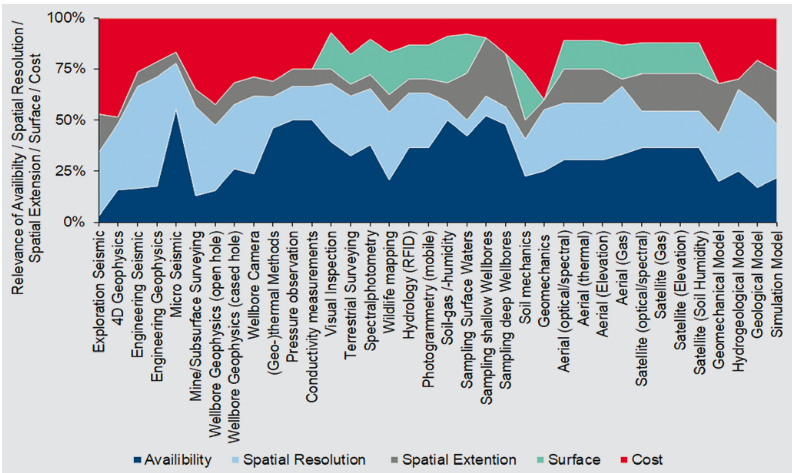

Fig. 4: Depiction of the scope and complexity of current geomonitoring tools (bold print = geomonitoring tools for TSF)

ing operation are to be treated and assessed on an integral basis [18].

When carrying out geomonitoring activities at tailings storage facilities it is not enough just to rely on data from Earth observation satellites such as Sentinel-1, whose mission forms part of the EU Copernicus Programme for mapping ground movements. Additional methods have to be employed, such as site visits, inspections and the setting-up of in situ sensors (bold print in **Fig. 4**).

When dealing with safety-relevant issues – of the kind that generally tend to arise during the lifecycle of a mining installation – risk management is of crucial importance. In order to be able to provide a reliable assessment of the risks arising from the operation of tailings storage facilities, and make appropriate adjustments to the operating regime, it is crucial to have in place as extensive as possible a (geo-)data, information and knowledge management system with 4D cover. This is directly linked to the geomonitoring of the entire mine site and its environment [19].

The results of a research project aimed at the detection of small-scale ground movements in an urban and non-urban environment can also be used to assist in the operation of tailings storage facilities (**Fig. 5**). In this case radar remote sensing, which is used for the detection of ground motion, is fed with a wide array of additional spatio-temporal information in order to identify any significant filtered ground movement. This digital operation, which is controlled and monitored by expert personnel, allows the basic geomonitoring measures, with all their periodic visits and inspections, to be reduced to an event-related level. At the same time the full integration of additional 4D datasets (such as meteorological data) (**Fig. 5**, stage 4 and stage 5) in the time series analysis of the radar data means that any changes can be identified at an early stage so that appropriate countermeasures and safeguards can implemented in good time. This can potentially help avoid or reduce future damage.

By this means any problems likely to impact on the integrity of the site can be recognised quickly and an understanding built up of the scientific and technical interrelationships involved, which is also validated by means of observations and measurements. The mining company can then use this process knowledge for internal and external communication so that the public and any relevant stakeholders can be included in his planning considerations right from the start [21]. While a holistic approach may initially hold up the project management and external project communication work, it will eventually promote a more resilient and sustained acceptance of the mining project.

Interpretation

Any mining process can only justifiably be referred-to as sustainable when the deposits in question are being exploited in line with appropriate sustainability targets. Geomonitoring takes broad-based account of these sustainability goals while at the same time limiting the environmental impact of the extraction process (**Fig. 6**). By providing for the complete digital integration of all the methods available, that is to say aerial (e. g. by satellite, overflying and drones), ground surface (site visits and in-situ sensors) and subsoil (e. g. borehole geophysics and mine survey measurements), it is possible to provide a transparent process understanding of significant events in space and time. This process understanding forms the basis for communication and hence for the development of the social licence to operate.

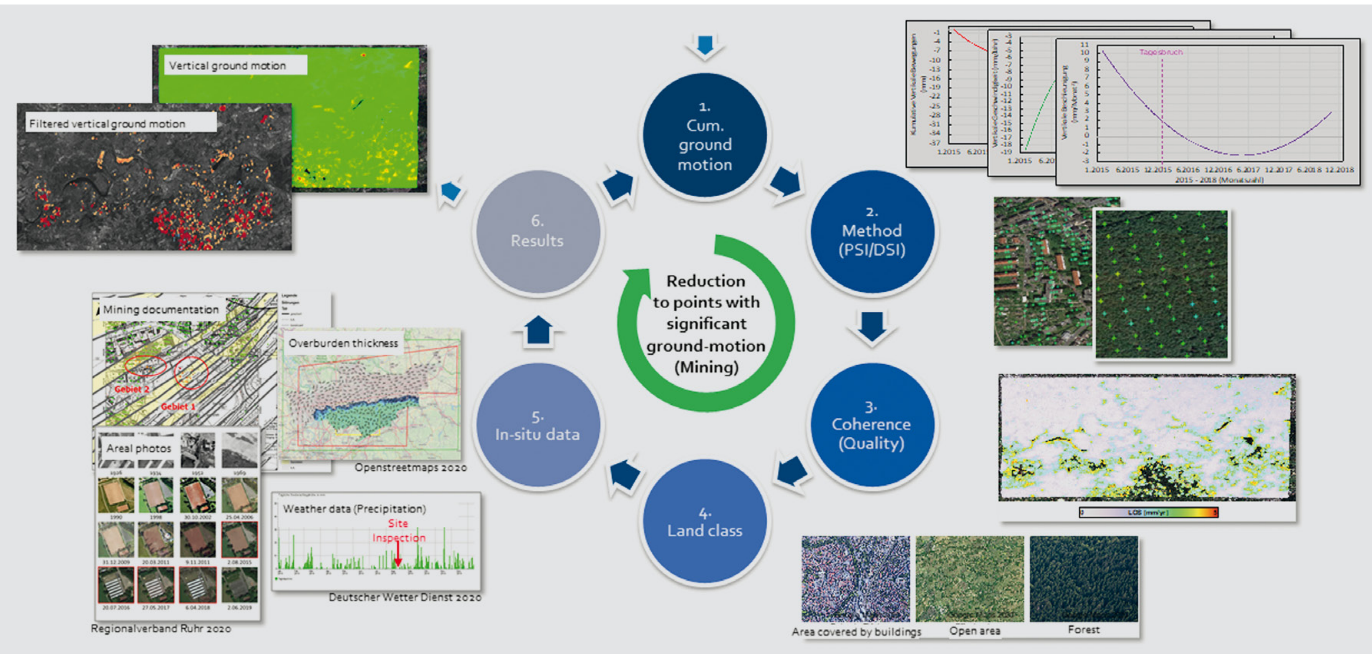

Fig. 5: Solution-oriented application of radar remote sensing incorporating additional information for the detection of small-scale ground movements (research project for the Ruhr basin)

The social acceptance of sustainable mining projects must cover the entire lifecycle of the mining installation from the initial planning concept right through to the closure phase and must in addition take account of the economic, ecological and social aspects of the overall operation. A development of this kind can only then be considered as sustainable when the activities being engaged in are fact-based and when sufficient transparency is provided through communication with all the parties involved. Given the specific physical and chronological parameters of the mining process and its dynamic mode of operation the need to maintain credibility and reliability in the eyes of the public at all times poses an enormous challenge for the mine operators. A continuous geomonitoring regime can provide an effective answer to this problem (Fig. 7).

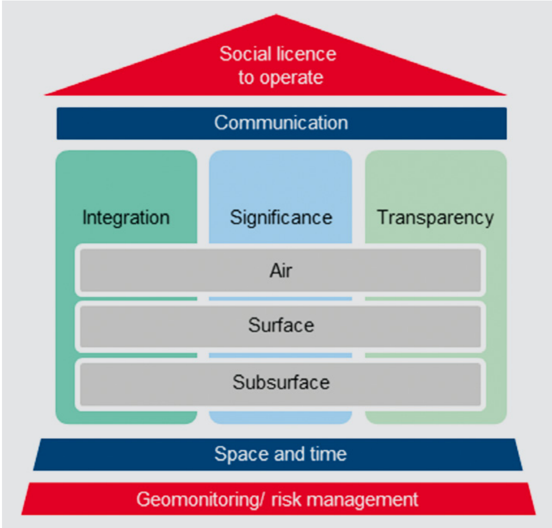

Fig. 6: Geomonitoring as a basis for communication and the social licence to operate

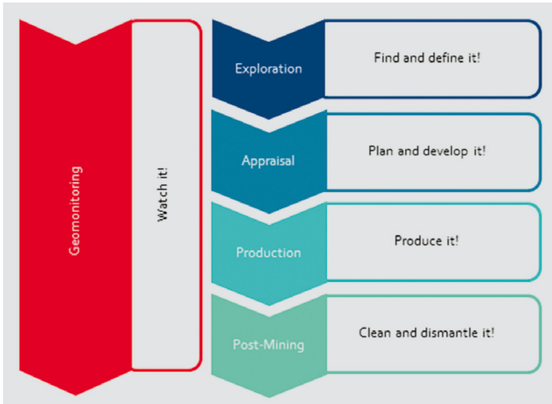

Fig. 7: Geomonitoring as part of the mining lifecycle

Conclusions

The various endeavours associated with the social licence to operate now have a primary role to play in the mining lifecycle and activities of this kind are very much in the public focus. At the same time current technological developments in our society (including digitisation and the widespread and rapid diffusion of social media), as well as the transition to a circular economy, have brought about a change of attitude that has seen a decline in the level of acceptance for, and the understanding of, the mining industry. This all generally ties in with a heightened need for information. In order to minimise the gradual loss of acceptance, and even to begin to reverse this process, greater provision has to be made for openness and for participation in the decision-making process by introducing, where possible, a transparent project management system along with a comprehensive set of integrated geomonitoring measures and target-oriented external project communication arrangements. The various technical geomonitoring tools that have become available can now provide the public with a real insight into the workings of the mining industry and the kind of operations involved. Furthermore, risk management methods mean that changes can be identified at an early stage so that countermeasures and safeguards can be implemented in good time. Incorporating a geomonitoring regime directly into the lifecycle of the mine is therefore the key to activating the social licence to operate required by those with responsibility for the management of tailings storage facilities.

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References

Rudolph, T.; Goerke-Mallet, P. (2021): Steigerung der gesellschaftlichen Akzeptanz im Management von Tailings-Storage-Facilities (TSF). GeoResources Zeitschrift (3-2021), S. 35–40. Online: https://www.georesources.net/download/GeoResources-Zeitschrift-3-2021.pdf

[1] Wellmer, F.-W. (2020): Bergbau – Energie – Geologie, Nachhaltigkeit und Rohstoffgewinnung – ein Widerspruch?. Bergbau 6:2020: 10 S., 13 Abb., 4 Tab.

[2] Wissenschaftlicher Beirat der Bundesregierung Globale Umweltveränderungen (WBGU) (2016): Der Umzug der Menschheit – Die transformative Kraft der Städte. Zusammenfassung. – 43 S., 2 Abb., 7 Tab.; Berlin: WBGU.

[3] Hiebel, M.; Bertling, J.; Nühlen, J.; Pflaum, H.; Somborn-Schulz, A.; Franke, M.; Reh, K.; Kroop, S.: Fraunhofer-Institut für Umwelt-, Sicherheits- und Energietechnik UMSICHT (Hrsg.) (2017): Studie zur Circular Economy im Hinblick auf die chemische Industrie. Studie im Auftrag des Verbands der Chemischen Industrie e. V., Landesverband NRW; 178 pp., 46 fig., 14 tables.; Oberhausen: Fraunhofer UMSICHT. – URN: urn:nbn:de:0011-n-4769003.

[4] Müller, F.; Kohlmeyer, R.; Krüger, F.; Kosmol, J.; Krause, S.; Dorer, C.: Röhreich, M. (2020): Leitsätze einer Kreislaufwirtschaft. 34 pp., 1 fig.; Dessau-Roßlau: Umweltbundesamt.

[5] Apaéstegui Campos, J.; Brandão, L.; Camargo de Azevedo, A.; Casanova, M.; Cord, A.; Gerner, N.; Giese, E. C.; Händel, F.; Jager, N.; Jessen, G. L.; Lepenies, R.; Maia Barbosa, P.; Marchezini, V.; Pujoni, D.; Salma, A.; Santos Sánchez, A.; Schierz, A.; Stemke, M.; Ussath, M.; Val, P.; Whaley-Martin, K.; Yoshie Yamamoto, F.; Zorzal-Almeida, S. (2019): A new vision of sustainable management in mining and post-mining landscapes. 30 pp., 6 fig.; Halle (Saale) u. a.: Deutsche Akademie der Naturforscher Leopoldina e. V., Nationale Akademie der Wissenschaften u. a. (Science Policy Report, October 2019).

[6] Agricola, G. (1556): De re metallica – Zwölf Bücher vom Berg- und Hüttenwesen. Nachdruck der Erstausgabe, 2006, 564 pp., VDI-Verlag, Wiesbaden

[7] Lin-Hi, N. (2018): Licence to operate. In: Gabler Wirtschaftslexikon. Revision von Licence to operate vom 19.02.2018 - 15:10. Online: https://wirtschaftslexikon.gabler.de/definition/licence-operate-51612/version-274773, state 4 June 2020

[8] Löhr, A. (2003): Interview: „Noch sind es nicht viele Firmen". Spektrum der Wissenschaft, 2003(12): 94. Online: https://www.spektrum.de/magazin/interview-noch-sind-es-nicht-viele-firmen/830326, state 4 June 2020

[9] Nelsen, J. L. (2007): Social license to operate: integration into mine planning and development. 127 pp., 21 fig., 5 tables; Master thesis, Vancouver, BC, University of British Columbia. Online: https://open.library.ubc.ca/cIRcle/collections/ubctheses/831/items/1.0081173, state 26 June 2020

[10] Black, L. (2013): The social license to operate – your management framework for complex times. 100 pp.; Oxford: DoSustainability (DōShorts series).

[11] DGMK-Veranstaltung / Aufsuchung und Gewinnung vom 28.05.2020; DGMK Webinar: Digital Transformation – The people component. Online: https://dgmk.de/veranstaltungen/dgmk-webinar-digital-transformation-the-people-component/, state 15 May 2020

[12] Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit (BMU) (2017): Nachhaltige Entwicklung als Handlungsauftrag. Stand: 16.08.2017. Online: https://www.bmu.de/themen/nachhaltigkeit-digitalisierung/nachhaltigkeit/strategie-und-umsetzung/nachhaltige-entwicklung-als-handlungsauftrag, state 20 October 2021

[13] Engagement Global gGmbH (Hrsg.) (2019): [Siebzehn] Ziele für nachhaltige Entwicklung. Online: https://17ziele.de/, state 4 June 2020

[14] Kleiner, M. (2016): Die Bedeutung von Stakeholder-Dialogen aus Sicht der Interaktionsökonomik – illustriert am Beispiel eines Bergbau-Unternehmens. VIII + 184 pp., 31 fig.; Leipzig: HHL Leipzig Graduate School of Management. Zugl.: Diss., HHL Leipzig Graduate School of Management. Online: https://slub.qucosa.de/api/qucosa%3A7816/attachment/ATT-0/, state 4 June 2020

[15] Geological Society (2021): Geoscience for the Future – Sustainable Development Goals. Online: https://www.geolsoc.org.uk/~/media/shared/documents/education%20and%20careers/Resources/Posters/geoscience%20for%20the%20future%20GERMAN.pdf?la=en, state 20 May 2021

[16] Goerke-Mallet, P. (1999): Aufstellung eines Rahmenbetriebsplanes mit Umweltverträglichkeitsuntersuchung – eine Herausforderung an das Kommunikations- und Informationsmanagement. Das Markscheidewesen in der Rohstoff-, Energie- und Entsorgungswirtschaft, 42(18).

[17] Pateiro Fernandez, J. B. (2008): Nachhaltigkeit im Bergbau. Indikatoren und Beurteilungssystem. 263 pp., 5 fig., 95 tables; Diss., RWTH Aachen. Online: https://d-nb.info/990723992/34, state 26 June 2020.

[18] Rudolph, T.; Goerke-Mallet, P.; Melchers, C. (2020): Geomonitoring im Alt- und Nachbergbau. Zeitschrift für Geodäsie, Geoinformation und Landmanagement, 145(3): 168-173, 5 fig.

[19] Goerke-Mallet, P.; Brune, J.; Möllerherm, S.; Kretschmann, J.; Rudolph, T.; Müterthies, A. (2020): Post mining analytics from space: an innovative approach to improve risk-management in mining. SME Annual Meeting, 23-26 Feb. 2020, Phoenix, AZ, Preprint 20-020, 3 pp.

[20] Rudolph, T.; Goerke-Mallet, P.; Janzen, A.; Müterthies, A.; Pakzad, K.; Spreckels, V.; Teuwsen, S.; Vehling, L.: Yang, C.-H. (2020): Bergbaumonitoring im südlichen Ruhrgebiet. In: Tagungsband Geomonitoring 2020, pp. 163-177. DOI: https://doi.org/10.15488/9348

[21] Lerch, F. (2020): Erfolgreicher Realisierungsdialog für E&P-Projekte – ein Beispiel. Erdöl Erdgas Kohle, 136(6): 21-23, 2 fig.

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