24-003

A Holistic Vision for a Systems Approach to Resource Governance

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ABSTRACT

Global public mineral reporting codes have driven strong governance of public disclosures of minerals information. Recently, we have seen an increase in disclosure of information related to Environmental, Social and Governance (ESG) issues, and governance of ESG information in mining companies has arguably reached a similar level of governance and diligence afforded mineral reporting. We define Resource Governance as the conjunction of environmental, social and minerals governance. A modern systems approach to Resource Governance, which combines mineral and ESG information, would provide not only reporting and governance capability, but also has the potential to sense/respond, predict, and manage ESG risks.

INTRODUCTION

The intent of this paper is to point out that there is a plethora of data that exists, is inter-related, is siloed, can be managed better in a more integrated way and in that world a company will be able to manage risk, see planning and operational performance better and as a result be *confidently transparent* with public disclosures. The intent is not to focus on sustainability or minerals reporting per se, but on the vision of value generation that a modern systems approach offers in this domain.

Public mineral reporting codes around the globe like S-K 1300 (2021), JORC (2012), SAMREC (2016), CIM (2014), PERC (2021) and CRIRSCO (2019) have driven strong governance of public disclosures of minerals information and the data that underpins those disclosures. These codes also require companies to disclose ESG matters that are material to the value proposition of their projects. In more recent years we have seen an increase in expectations of transparent public disclosure of information related to ESG issues, driven by investors and supply chains. Governance of these types of information in mining companies has arguably reached the same maturity as information that supports mineral reporting, which opens opportunities for a broad-based approach across all these domains. See Rowland et. al. (2023) for a summary of standards that relate to ESG reporting.

To further improve ESG and minerals reporting mining companies must overcome challenges related to disparate sources and quality of data, large numbers of stakeholders, siloes in the organisation, varying levels of technical and social competence, and the strength of mechanisms for business process control including approval of public disclosures. These challenges are non-trivial but can be overcome, and exciting opportunities for improvement realized, by taking a holistic systems view of "Resource Governance."

In this paper we define Resource Governance as the *conjunction of environmental, social, and mineral governance*, which has a spatial and business process foundation. Like Edmans (2023), who suggests "ESG is both extremely important and nothing special," our holistic systems approach is consistent with a focus on *all* long-term value drivers and not singling out ESG by itself as a value driver. ESG should not be treated as a niche area of interest but as an integrated part of the whole.

By conceptualizing Resource Governance in this way, we envision an integrated systems approach to data management, accountability, authority, process control and public disclosure that combines spatial information and traditional data systems to enable a greater level of transparency internally and externally for a mining business. The Resource Governance vision presented here can help the mining industry *combine* discussion of environmental, social, and mineral governance issues, which are *interrelated* (Rowland et al, 2023).

After defining Resource Governance, a summary of the types of information that fall within scope of this vision are described. Following this is a discussion of common problems and opportunities related to business process control and then a description of the potential benefits of taking a holistic systems approach. Prior to concluding, we offer some ideas about the application of advanced analytics that are made possible by adopting the proposed holistic systems approach to Resource Governance.

DEFINITION OF RESOURCE GOVERNANCE

The (very simplified) domains of Resource Governance are shown schematically in Figure 1. There are many more dimensions to Resource Governance than can be accommodated in a simple figure, the idea here is that in the past the data, systems and processes have been segregated and siloed, and a more holistic systems view is possible. Highlighted on the left side are what we refer to as 'Natural Resource Governance', which relates to the natural capital in, on and above the surface of the earth typically centered around license to operate matters, and 'Mineral Resource Governance', which relates to matters in the sub-surface domain (leaving surface stockpiles aside).

Both these domains exist under the same spatial footprint and interact in substantive ways to define the constraints and potential of a mining project. On the right side is shown Resource Governance encapsulating both Natural and Mineral Resource Governance domains, which are often treated separately by mining companies in various ways.

From a business process perspective, the Natural and Mineral Resource Governance domains have often been managed separately because of the different expertise involved, different types of activities, different locations, and the daunting breadth of issues involved. The people and processes involved in Mineral Resource and Mineral Reserve definition, mine planning and design, and operating a mine have been separated from the people and processes involved in addressing the Natural Resource Governance matters, which constitute establishing and maintaining the licenses to operate. We believe that Resource Governance expectations from regulators and society will be better served by establishing a conjoined and aligned knowledge base, which enables digitally encoding business processes and governance across the organisation. What this means is that there is irrefutable traceability along the data chain that ensures accountability for public disclosures, and those disclosures are intrinsically aligned to the licenses to operate.

RESOURCE GOVERNANCE INFORMATION

To illustrate the breadth, scope, and complexity of the Resource Governance challenge, Figure 2 shows examples of the types of issues that drive subject matter experts to collect, interpret, and model information related to Resource Governance.

BUSINESS PROCESS CONTROL

As can be seen in Figure 2 there are many functional areas relevant to Resource Governance, many of which are interrelated. Each functional area in a mining company will comprise individuals and teams, both internal and external, working to plan, acquiring data, making sense of information, drawing conclusions, and proposing actions. Rapidly, the number of people involved, the complexity, and the interdependency of business processes becomes a substantial challenge to manage in an efficient and well governed way.

Traditional management approaches result in siloes of people focused almost exclusively on their own functional area (swim-lanes), working to deliver against key performance indicators that describe the things they have control over and can reasonably be measured against. The corollary of this approach is that data management, interpretation and modelling within a function also become siloed. By its very nature, this type of organisation will:

- Struggle to share information across functions,
- Miss opportunities for collaborative solutions to problems,
- Duplicate efforts,

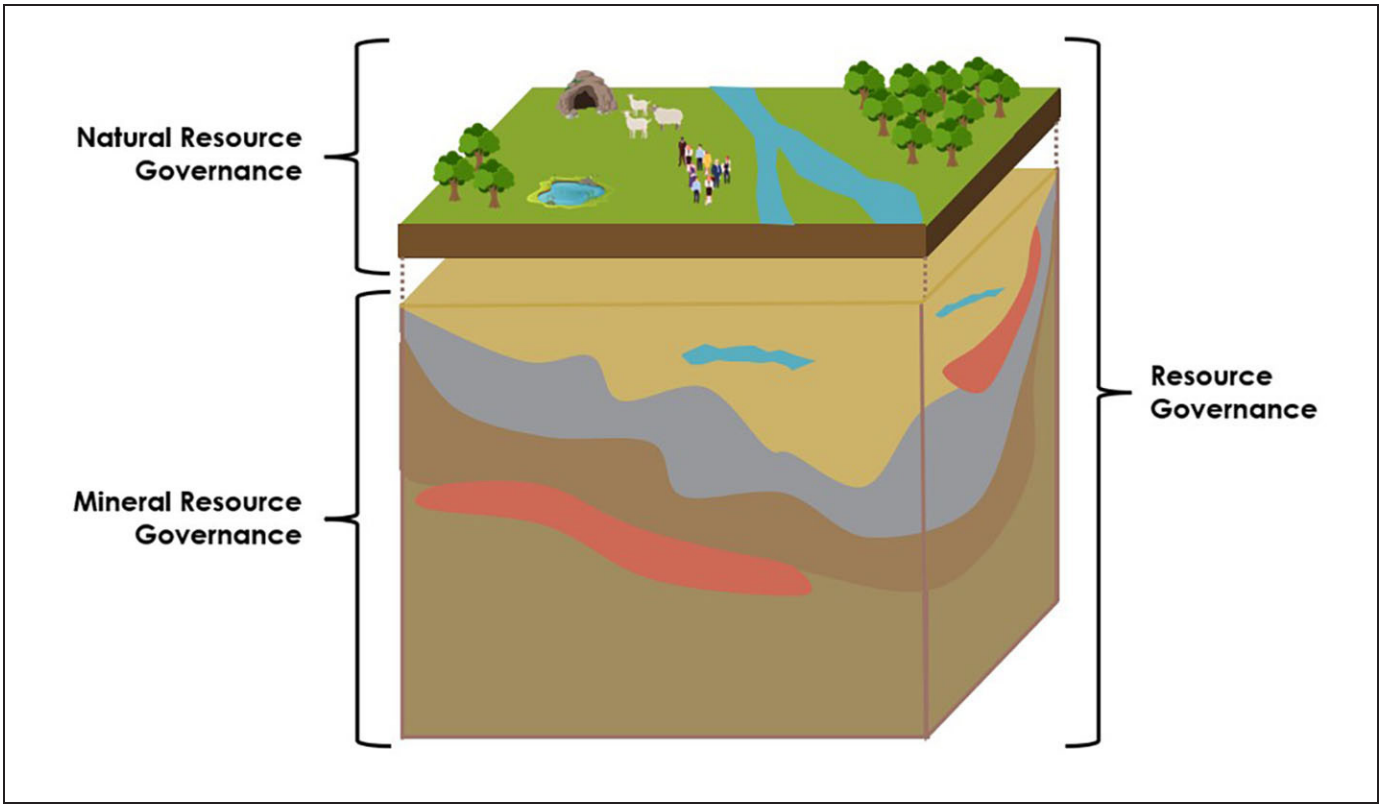

Figure 1. Definition of Natural, Mineral and Resource Governance domains

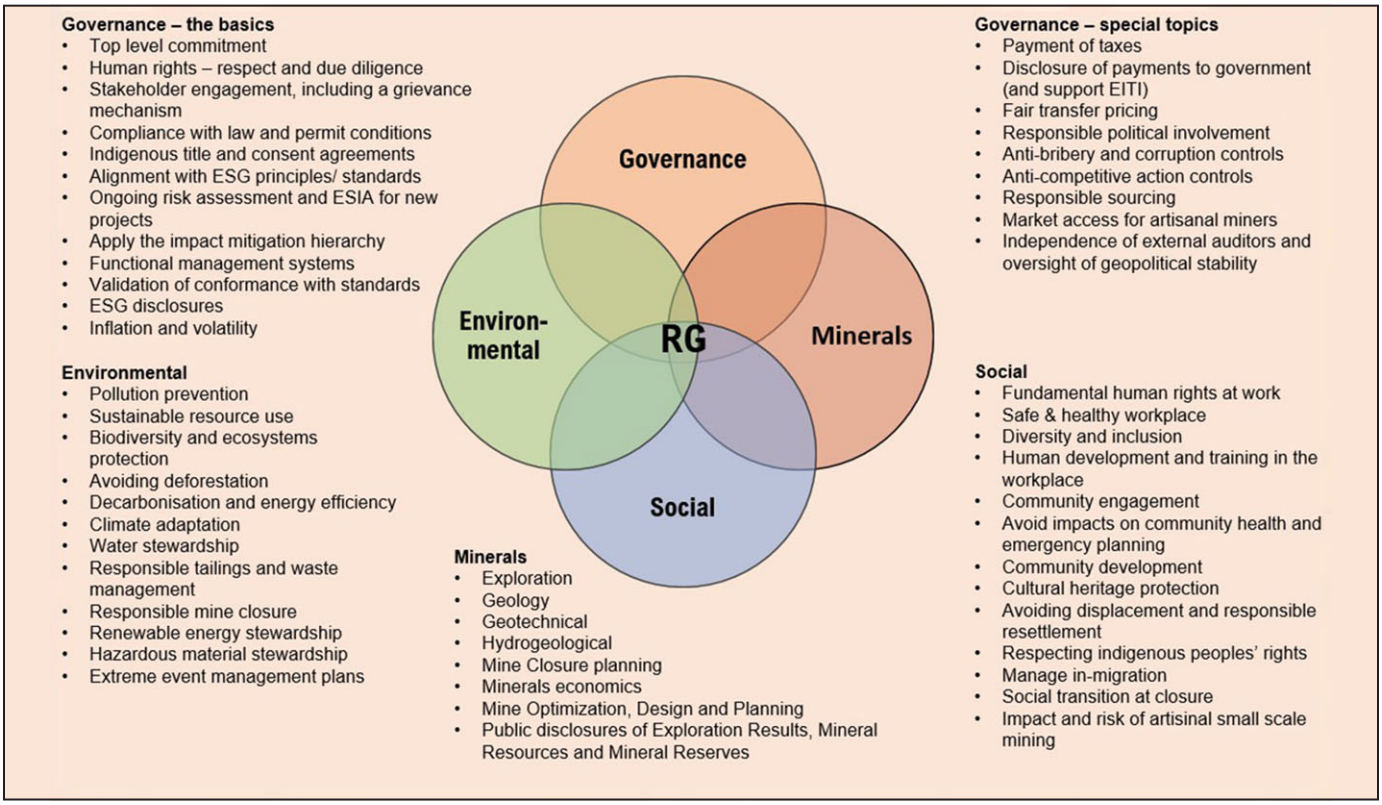

Figure 2. Resource Governance topics (adapted from Rowland et al, 2023)

- Struggle to see the big picture and appropriately allocate funding to the most value-adding initiatives,
- Struggle to forecast events accurately because one function is blind to the events or requirements of other functions,
- Be almost immune to change displaying high levels of organisational inertia, and
- Be nervous about signing off on public disclosures due to all the points listed above.
- Clearly these business functions are inherently symbiotic, yet the current structures, operational processes and data structures inhibit leverage and mutual benefit.

There is a need to change this organisational paradigm, and at the same time avoid reinventing the entire enterprise. The needs of people and of the business can both be satisfied when the siloed nature of the business is identified and removed as a cause of inefficiency, duplication, and poor governance. This does not necessarily entail reorganizing people, but rather adopting a holistic systems approach centered around a common understanding and usage of interrelated data (a data ontology), which has the following features:

- Access to information is available to everyone who needs it,
- Spatial data is available to everyone from the same source system and is easily visualized and contextualized relative to other data types,
- The relationships between people, physical entities and business processes are encoded into the system – roles and responsibilities are mapped to the information and work that needs to be done,
- The obligations the company has made to government, regulators and other stakeholders are intrinsically linked to spatial data objects and to the people who need to do work related to those obligations,
- Milestone dates and events automatically trigger the right work at the right time such that the company never fails to meet its obligations, and
- Digital workflows manage data capture events, validation and review, presentation of information and approval of content. Multilevel approvals are catered for, whether in series or in parallel. These workflows form the backbone of governance because they record who did what, when, and who ultimately had accountability and responsibility.

There are clear and substantial benefits to be gained from a holistic systems approach, which are detailed in the next section.

BENEFITS OF A HOLISTIC SYSTEMS APPROACH

A holistic systems approach to Resource Governance provides companies with a more comprehensive understanding that can drive meaningful change, comprehensively manage risk, achieve sustainable growth, and contribute positively to the environment and society. Companies that adopt a holistic systems approach to Resource Governance will see a clear picture of their impacts, can embed sustainability in the overall business strategy, are able to optimize resource allocation, and become *confidently transparent*. With a holistic systems approach, stakeholder engagement and risk management are more effective and lead to the fostering of long-term value creation.

Integrated Decision-making

Firstly, it is critical to recognize that Resource Governance issues are interconnected and will have overlapping impacts. With a holistic systems approach, companies can fully consider the interdependencies and trade-offs in environmental, social, and mineral governance factors. If organisational functions can integrate the decisionmaking process, comprehensive solutions can be identified across multiple dimensions simultaneously.

Avoiding Reputational Damage

Two recent events suggest that the 'federated' organisational model seen in many mining companies is not sustainably meeting society's expectations of Resource Governance performance:

- Tailings dam failures leading to the release of the Global Industry Standard for Tailings Management (GISTM, 2020), and
- The Australian Federal Parliamentary Inquiry into the destruction of significant heritage sites at Juukan Gorge (AFP, 2021).

The 'federated' model is one where multiple business units operate independently or semiindependently of a central corporate entity. Some are grouped by region or commodity but maintain local decision-making rights. However, when disasters occur, it hits all levels of the organization, with damage to reputation being felt most keenly by the corporate entity (e.g., WWF, 2020).

There are variations and degrees of control from the corporate centre, ranging from very little control outside financial reporting and policy setting to higher levels of control where the corporate centre maintains teams of technical experts that work in parallel or oversee operational functions to ensure they are meeting corporate,

industry and regulatory standards. A holistic systems approach would enforce the Golden Thread (Rowland et al, 2023) of Resource Governance strategy at the highest level to operational practices at site level, which is essential if companies are to deliver on their intentions and promises to stakeholders.

With a holistic systems approach, it is possible to identify synergies and minimize conflicts that arise from implementing solutions to governance issues that arise. Focusing on issues in isolation can lead to unintended consequences/risks or sub-optimal trade-offs. As an example, creating a mine plan that optimizes financial gains in the short-term without considering longer term social or environmental impacts that may harm a company's reputation as well as damage stakeholder relationships. As mining companies take a systems approach and perform integrated planning to maximize their supply chain performance while being mindful of upstream and downstream dependencies and consequences, so must they also manage their Resource Governance knowledge base in the same "systems" way.

Stakeholder Expectations

A company's commitment to long-term value creation and responsible business practices can be demonstrated within the framework of a holistic approach. Stakeholders increasingly expect companies to demonstrate a comprehensive commitment to Resource Governance challenges. Enhanced stakeholder trust and loyalty can be achieved by embedding an approvals workflow that pro-actively, confidently, and transparently authorizes information disclosed in the public arena.

When evaluating projects or operations economically, mining companies must know the risk associated with projected cashflows and return on investment. From that perspective, a holistic systems approach can not only allow wise capital allocation across different projects, but also increase stakeholders' awareness of cashflow sensitivities when incorporating a wide range of social and environmental risks in their projections.

Future-proofing Regulatory Compliance

Governance regulations and reporting requirements are constantly being changed and updated. Within the framework of a holistic systems approach, which entails a comprehensive knowledge base, companies are much better prepared for future regulatory requirements and can more easily comply with emerging standards as they are introduced.

Circumstances arise, such as they have recently in Eastern Europe, where regulators may ask mining companies to declare how much of their mineral inventory is in high-risk locations, a request that demonstrates the value of a holistic systems approach to Resource Governance.

In addition, a company that takes a holistic systems approach is well positioned to defend itself from accusations of greenwashing because it will have the ability to demonstrate alignment between its Golden Thread (Rowland et al, 2023) and its performance, it will be able to show internal accountability and an audit trail leading from data to a decision.

Risk Management

When solutions are applied to Resource Governance issues in an integrated manner, risks can be identified and managed comprehensively such that a company can proactively mitigate risk, adapt to evolving market conditions, and enhance a company's resilience against shock events. Drawing on a central source of spatial, people and business process information, data scientists can tap into these vast heuristics bases and study past performance and live data feeds to predict future events. This type of capability is highly valuable because it provides the organisation with the opportunity to avoid or mitigate failures before they occur. An example of this approach to managing ground disturbance and associated ESG risks is detailed in Spence, Arvidson and Helm (2023).

Innovation and Competitive Advantage

Applying a holistic systems approach allows a company to evaluate the mine value chain and identify opportunities for innovation which in turn leads to the creation of novel solutions, delivery of operational efficiencies, attraction of new customers, and tapping into new markets. These behaviors and outcomes can lead to a competitive advantage.

Long-Term Value

It is important for companies to recognize that Resource Governance challenges are long-term issues that require a forward-looking perspective. If companies integrate Resource Governance considerations into their forward-looking core strategies, they will be able to foster and encourage long-term value creation. This eliminates reactive short-term fixes and superficial actions, which lead to unsustainable performance.

ADVANCED ANALYTICS FOR RESOURCE GOVERNANCE

The application of advanced analytics across mining is a well-trodden path. Arguably all mining companies employ analytics at varying levels across multiple areas of their

business – some obvious examples being in predictive asset management and supply chain optimization. It is time that Resource Governance data, analytics technologies and experience be applied to the critically important topic of Resource Governance.

Construction of a central source of all Resource Governance information creates opportunities for advanced analytics techniques to provide 360-degree views of land holdings, obligations, and stakeholders. The following sections explain the vision of what could become a new paradigm in Resource Governance.

360-Degree View of Land Holdings

For each geospatial land area, managers of a mining company can have a complete and proactive view of obligations, risks, stakeholders, milestone dates, who is working where, status of permits to work, no-go zones, points of conflict, points of intersection and impacts on operational schedules. Changes in the status of any of these dimensions can automatically trigger notifications to the right people to review the new conditions and take necessary steps.

360-Degree View of Obligations

For each obligation a mining company will be able to see a complete picture and proactively manage all stakeholders involved, workflows and approval chains, compliance risks, points of leverage, points of similarity to other obligations, which allows for operational efficiency in meeting all obligations. Managers could have access to a continuously updated, comprehensive dashboard showing high priority risks, due dates, and stakeholder concerns. Additionally, using advanced analytics, managers will be able to track trends that could lead to noncompliance as well as track trends that reveal emerging opportunities to create value.

360-Degree View of Stakeholders

For each stakeholder it should be possible to see a complete picture of obligations, approvals, emerging issues, opportunities to negotiate and ways to combine and leverage commercial arrangements.

For stakeholders a self-service portal could be established that allows them to be fully informed, which has the added benefit of reducing the burden on the mining company of serving those stakeholders in answer to requests for information. This might include:

- Status of agreements,
- Due dates, what is coming up or overdue,
- What is the stakeholders' net position with the mining company, and
- Provide auditable 2-way communication channels.

Analytics

Descriptive analytics would typically include things like:

- Dashboards and reports,
- Analysis of historical data on lease expiration, disputes, renewals, etc.
- Analysis of heritage non-compliance, and
- Analysis of frequency, duration, and success rate of permit applications.

Predictive analytics might extend this further to include:

- Time series forecasting,
- Churn prediction,
- Predictions of environmental impacts of proposed activities,
- Proactive management of expiration of tenements, permits and disputes,
- Proactive estimation of likely timeframes for gaining permits based on past performance, and
- Forecasting potential heritage risks for future mining activities.
- *Prescriptive analytics* might include the following:
- Supply chain performance and sustainability,
- Ethical investment guidance,
- Community engagement,
- Regulatory compliance strategies,
- Risk management strategies, and
- Tailored engagement strategies for stakeholders.

All the above transformational use-cases are predicated on a common understanding and management of Resource Governance data, an appropriate data ontology, and a standardized means of leveraging the data (these would typically be provisioned by API's (Application Programming Interfaces) and/or a Data Access Layer).

CONCLUSION

In this paper we have established a definition of Resource Governance as the conjunction of environmental, social and minerals governance, then outlined a vision for a holistic systems approach to Resource Governance that embraces the full gamut of issues above and below ground for a mining project. We then highlighted common problems and opportunities related to business control processes, explored the potential benefits of a holistic systems approach, and pointed out the possible applications of advanced analytics to Resource Governance.

We believe the technology is available today to make this Resource Governance vision a reality and the value proposition appears highly compelling given the current environment of societal expectations of the mining

industry, limited availability of human resources, regulatory requirements, and stock exchange reporting rules.

A holistic systems approach to Resource Governance allows a company to navigate the current environment more effectively, prepares it to capitalize on opportunities and create sustainable value for both the business and the society it operates in. Addressing ESG matters in isolation may show incremental improvement, but a holistic systems approach to Resource Governance recognizes the uniqueness and complexity of each individual project, the long-term nature of mining projects and the interconnectedness of the mining value chain.

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24-004

A Study on the Impact of In-Seam Rock Partings on Coal Pillar Strength Based on Field Instrumentation and Numerical Modeling at the Maple Eagle Mine

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ABSTRACT

In an effort to advance the science underlying modern coal pillar stability analysis, researchers at the National Institute for Occupational Safety and Health are currently involved in research aimed at better understanding the impact of an in-seam rock parting on the strength of coal pillars. The purpose of this study is to determine a suitable virtual mining height that could be applied using current pillar stability analysis tools. To accomplish this, the boundary element model LaModel was used to back analyze data collected on pillar performance in a room-and-pillar panel at the Maple Eagle Mine located in Southern West Virginia.

In a previous work, data collected from borehole pressure cells (BPCs) and extensometers were taken from three instrumentation sites. Data collected from the back bleeders were used to measure the rear abutment stresses, and data collected from two instrumentation sites in the wrap-around bleeder were used to measure the front and side abutment stresses as well as the peak strength and performance of the slabbed leave pillar. The utilization of two nearly identical instrumentation sites in the wrap-around bleeder provided much needed repeatability of the obtained measurements.

In this study, the data collected from BPCs at the three instrumentation sites was calibrated to match the Bieniawski pillar stress gradient. To model the measured pillar behavior, the LaModel program was selected due to its capability of being directly comparable to the Analysis of Retreat Mining Pillar Stability (ARMPS) and Analysis of Coal Pillar Stability (ACPS) programs. The model was then calibrated to match the measured abutment extent and abutment stress. Finally, the model was validated by reducing the modeled mining height until the yielding of the slabbed leave pillars in the model matched what was measured in the field.

The final calibrated mining heights show that a reduction of the shale parting thickness, not including any clay layers, of 52% is applicable. This research study provides the first known measurement of the ARMPS/ACPS "50% Rule" and its applicability to this panel of the Maple Eagle Mine. This finding provides a proof of concept and could have significant implications for future research.

INTRODUCTION

One of the primary challenges in underground coal mining is ensuring the stability of the mine structure, particularly the pillars that support the overlying strata. In the Central Appalachian region, the unique geological formations are complicated by factors such as varying depths of cover, geological anomalies, and the presence of in-seam partings. These complexities necessitate a thorough understanding of pillar behavior under different mining conditions