Gem Trail Lab

1ST INTERNATIONAL

SUSTAINABLE GEM RESEARCH SYMPOSIUM

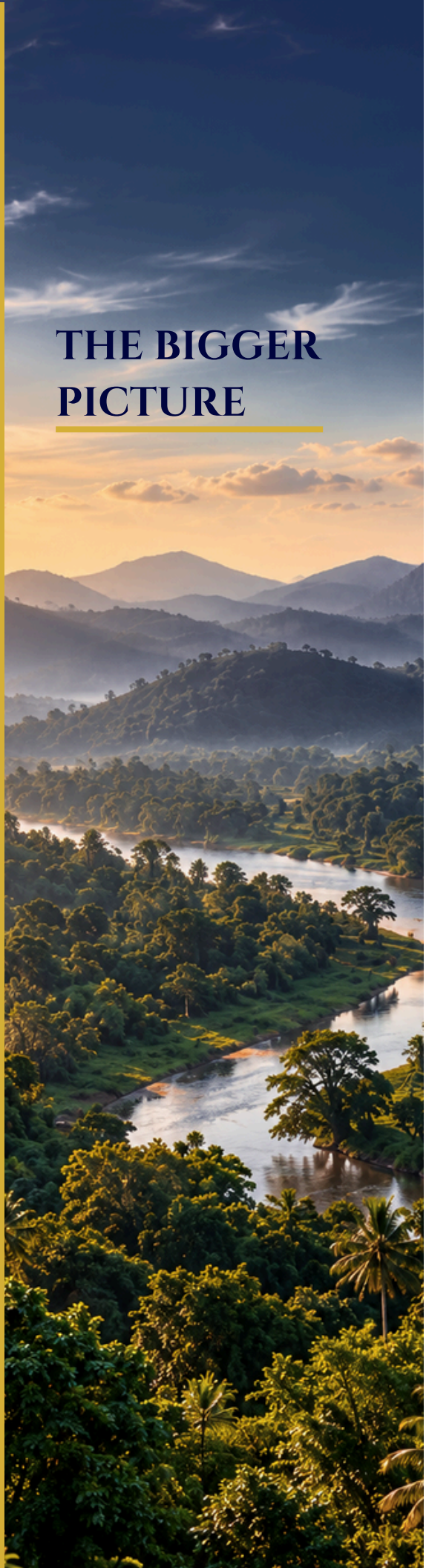
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Symposium Publication



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TRACE Expert City,
Colombo, Sri Lanka



THE BIGGER PICTURE

When we think of gemstones, we picture polished gems valued by their cut, colour, clarity and carat - and perhaps even ask a seemingly simple question: Where did this gemstone come from?

Yet a gemstone's story goes far beyond its origin. From extraction to the final market, each stone passes through a complex journey involving people, communities, environments and often fragmented supply chains. Understanding this journey is essential to building a more transparent, responsible and sustainable gemstone sector.

Unlike diamonds or commodities such as coffee and tea, where traceability and certification frameworks have developed over decades, the coloured gemstone industry remains highly fragmented. Diverse mining practices, informal trading networks and international supply chains make verifying provenance particularly challenging. Addressing these challenges requires bringing together perspectives from science, nature, livelihoods, technology and trade.

Against this backdrop, Gem Trail Lab convened the 1st International Sustainable Gem Research Symposium on 22 September 2026 at TRACE Expert City in Colombo. Bringing together researchers, industry professionals and technology practitioners, the symposium explored how science and innovation can contribute to a more sustainable gemstone sector.

Rather than offering a single answer, the symposium aimed to share emerging research, connect perspectives and inspire future collaboration -keeping the people, communities and environments behind gemstones at the heart of the conversation.

Manuel Kreitmeir

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Symposium at a Glance

107
Registrations

10
Sessions & Discussions

13
Speakers & Contributors

04
Universities represented

Countries Represented (online & in-person)

Sri Lanka | Germany | Madagascar | France | Japan | Switzerland

Research & Dialogue Across

Gemology | Gem Mining | Biodiversity | Traceability | Sustainability | Future of the Gem Industry

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PROGRAMME OVERVIEW

1:10pm - 1:25pm	Academic Keynote – Emeritus Prof. P.G.R. Dharmaratne, University of Moratuwa
1:25pm - 1:45pm	Guest Keynote: Sustainability, Transparency & Responsible Value Chains – Prof. Laura Marie Edinger-Schons, University of Hamburg
1:45pm - 2:00pm	International Research Presentation : Advanced X-ray Technology for Gem Traceability - Prof. Florian Grüner, University of Hamburg
2:10pm - 2:25pm	Research presentation 01: Characterization of Gems and Gem-Bearing Ores with a View to Their Depositional Localities in Ratnapura District, Sri Lanka – Prof. H. M. R. Premasiri and research team, University of Moratuwa
2:25pm - 2:40pm	Research presentation 02: Geotechnical Applications for Gem Open-Pit Mining Operations in Ratnapura District, Sri Lanka – Dr. G. V. I. Samaradivakara and research team, University of Moratuwa
2:50pm - 3:05pm	Research presentation 03: Influence of Locality on Colour Enhancement of Heat- Treated Milky Geuda from Sri Lanka; A Mineralogical and Geochemical Investigation - T.G Ramesh, R.G.C Jaliya, S. Illangasinhe, P.K.S.S.Alwis, Uva Wellassa University
3:30pm - 4:00pm	Panel Discussion: Current and Future State of Sri Lanka's Gemstone Industry Heminda Jayaweera, Visaka Ellawala, Emeritus Prof. P. G. R. Dharmaratne
4:00pm - 4:15pm	Future Research Discussion : Listening to Biodiversity: A Proposed AI-Based Study of Bird and Frog Vocalisations in Gem-Mining Landscapes - Prof. Dr. Sampath S. Seneviratne, University of Colombo
4:15pm - 4:30pm	Future Research Discussion: Architecture of Transparency: Power and Evidence Control in Informal Gemstone Supply Chains - Isabel Henning, University of Hamburg
4:30pm - 4:50pm	Industry Conversation & Demonstration: Digital Product Passports and the Future of Sri Lankan Gemstones — From Provenance to Ethical Luxury — Vandana Hettiaratchi, Gem Trail Lab

KEYNOTES



Whither gem industry of Sri Lanka

Emeritus Professor P.G.R Dharmaratne | University of Moratuwa, Sri Lanka

About the Keynote



The opening keynote by Emeritus Professor P.G. R. Dharmaratne explored the historical development of Sri Lanka's gem industry, including the distribution and scale of the country's
gem resources and its traditional artisanal mining practices. Comparisons were drawn with mechanised mining models, particularly in Thailand. The keynote also addressed responsible mining, worker protection and benefit-sharing, before examining current challenges facing Sri Lanka's gem and jewellery sector and outlining priorities for strengthening the country's position in the global gem industry.

Key Insights

Sri Lanka's gem heritage and resources

Sri Lanka's gem industry is rooted in a long history of artisanal mining and trade. The keynote highlighted the extent of the country's gem-bearing areas and the continued importance of traditional mining practices, which remain fundamentally different from more mechanised extraction models found elsewhere.

Responsible mining and benefit-sharing

Particular attention was given to the social dimensions of gemstone mining. Worker safety, appropriate mining practices and the distribution of benefits among those involved in mining were highlighted as important considerations in maintaining a responsible and sustainable sector.

Learning from international gem centres

Thailand was presented as an important point of comparison. Despite limitations in its domestic gemstone resources & declining mining extraction, the country has developed a significant international gem and jewellery industry by sourcing stones internationally and building capabilities in processing, trading and value addition. This raises questions about how Sri Lanka might similarly expand its role beyond domestic extraction.

Strengthening Sri Lanka's future position

The keynote highlighted several challenges facing the sector, including the emergence of synthetic gemstones and increasingly sophisticated treatments, the need for stronger testing and certification capabilities, and the importance of managing domestic gemstone resources responsibly. Greater value addition, international sourcing and stronger technical infrastructure were identified as areas relevant to Sri Lanka's future competitiveness.

Implications for the Gemstone Sector

The keynote highlighted the need for Sri Lanka to consider its future in the gemstone sector beyond the extraction of domestic resources alone. The comparison with Thailand illustrated how a country can strengthen its position as an international gem and jewellery hub through trading, processing and value addition, including the sourcing of gemstones from other producing countries.

At the same time, maintaining Sri Lanka's distinctive artisanal mining tradition requires continued attention to responsible resource management, worker safety and equitable benefit-sharing. Strengthening these practices can help preserve the social and economic value generated by small-scale mining while addressing sustainability concerns associated with extraction.

Advances in synthetic gemstones and gemstone treatments also increase the importance of strong technical capabilities. Investment in modern testing infrastructure, specialist expertise and credible certification could therefore play an increasingly important role in protecting market confidence and supporting Sri Lanka's international competitiveness.

Taken together, the keynote pointed towards several areas of strategic importance for the sector:

- responsible management of domestic gemstone resources;
- stronger worker protection and mining practices;
- greater domestic processing and value addition;
- development of internationally credible testing and certification capabilities
- a broader role for Sri Lanka in international gemstone sourcing and trade.

Key Takeaway

Sri Lanka's future as a global gemstone hub depends not only on its natural gem resources, but also on how effectively it combines responsible mining with stronger value addition, international sourcing, and credible testing and certification capabilities.

When Origin Becomes Verifiable: Why Traceability Changes Markets

Prof. Laura Marie Edinger-Schons | University of Hamburg. Germany

About the Keynote



The international keynote by Professor Laura Marie Edinger-Schons opened with the need to move beyond the gemstone's physical characteristics - cut, colour, carat, price- to consider its origin, people, journey and impact. Social and environmental externalities hidden within global gemstone value chains were discussed by looking at information asymmetries and power imbalances, illustrating the challenges of traceability in the coloured gemstone sector. The presentation also highlighted the market importance of origin and responsible sourcing, the shift from sustainability claims to evidence and verification and the role of technology in making provenance more verifiable. The keynote underscored the potential for traceability to influence transparency, accountability and market incentives and concluded by highlighting the opportunity for Sri Lanka to strengthen its position in the global gemstone sector through leadership in traceability and verifiable provenance.

Key Insights

A gemstone has two stories

The presentation emphasised on the two-sided story of a gemstone - its traditional value centered on physical characteristics and the price and how sustainability cannot only be understood through the characteristics of a finished gemstone. It is necessary to consider the other side - the stone's journey where origin, mining conditions, chain of custody, social and environmental impact play a part in the broader product story.

Complex and opaque gemstone supply chains

The gemstone supply chain is highly fragmented with multiple intermediaries and changes of ownership before reaching the final market. Gemstones are unique physical products that transform with cutting and treatment, making standardised tracing difficult. Origin information can be difficult to independently verify. Informal relationships and trust function as part of the sector's governance system. Informal trade and under-declaration mean that official statistics capture only part of the global gemstone trade. This creates information asymmetries and unequal power dynamics that can disadvantage miners and gem producing countries, while better-informed actors may capture a greater share of value. Limited transparency can further obscure social and environmental risks, with provenance potentially remaining unverified even at major international trading centres.

Origin is increasingly becoming part of the product proposition

The presentation stressed the growing attention frominternational jewellery brands and customers towards provenance, origin information and responsible sourcing, which is connected to brand reputation and consumer trust. This is further emphasized by increasing expectations for sustainability and origin claims to be verified and substantiated. The transition from the voluntary "trust me" to "show me" shows that traceability is more than just documentation. It is accountable and verifiable evidence, through independent verification.

From digital traceability to verifiable markets

Digital systems can preserve information across the gemstone journey, but they cannot guarantee that the original data is correct. Digital traceability and physical verification are therefore complementary, combining recorded information with evidence from the gemstone itself. More verifiable provenance can strengthen transparency and accountability, potentially influencing reputation, risk, market access, price and bargaining power across gemstone supply chains.

Implications for the Gemstone Sector

The keynote highlighted how verifiable provenance could move traceability beyond documentation and become a driver of broader market change.
Key implications include:

- Evidence-based traceability - moving from origin claims towards verifiable evidence.
- Physical and digital integration - combining digital records with scientific verification of the gemstone itself.
- Transparency and accountability - increasing visibility of origin, conditions and impacts across fragmented supply chains.
- Market differentiation - credible provenance potentially influencing reputation, market access and value.
- Value distribution - better information potentially changing bargaining power and how value is captured across the supply chain.
- Opportunity for Sri Lanka - using verifiable provenance to strengthen its position as a responsible and innovative gemstone-producing country.

The keynote concluded with three questions for the future:
1. **Can we know?** Can technology reliably establish provenance?
2. **Will we know?** Will actors share and connect information?
3. **What happens when we know?** How might verifiable provenance change prices, power, responsibility and value creation?

Key Takeaway

Traceability becomes transformative when origin moves from a claim to verifiable evidence. Combining credible information, physical verification and digital traceability can strengthen transparency and accountability while potentially changing how trust, risk and value are distributed across gemstone markets.

RESEARCH HIGHLIGHTS



Advanced X-ray Fluorescence Imaging: A Possible New Approach for Gemstone Traceability

Prof. Florian Grüner | Center for Free Electron Laser Science, Institute for Experimental Physics, Universityof Hamburg, Germany

Research Context

X-ray Fluorescence Imaging (XFI) is a highly sensitive imaging approach for tracking and detecting labelled entities, including cells, medical drug compounds, nanoparticles and antibodies. The key strength of the XFI approach is the unprecedented level of sensitivity combined with spatially resolved information. The same underlying physics can be applied to gemstone analysis, where sensitive detection of trace elements could provide information for distinguishing gemstones.

Research Objective

The research explores whether highly sensitive XFI measurements could provide a physical signature capable of distinguishing gemstones from different mining locations, and therefore potentially contribute to gemstone traceability.

Approach and Technology

XFI uses an incident X-ray beam to excite atoms within a material, causing them to emit characteristic X-ray fluorescence. A major challenge is separating these signals from the spectral background, particularly where trace elements occur only in very small quantities.

The University of Hamburg developed SCOTTI (Super Compact Optics-based Tunable Testbed for Imaging), a laboratory-scale XFI system designed to achieve the sensitivity previously associated with large synchrotron facilities.

Proof of Concept

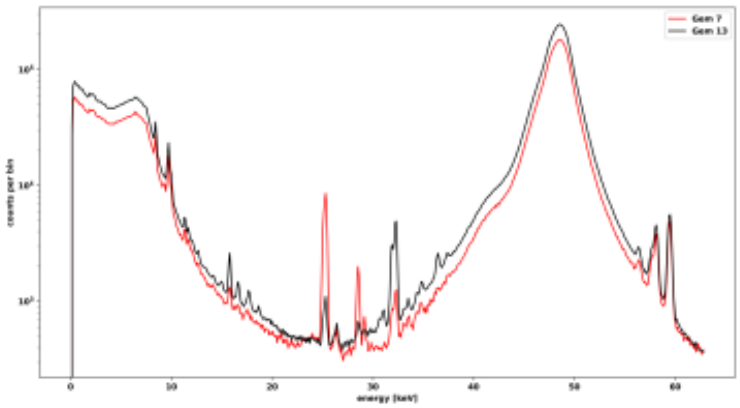
The first gemstone proof-of-concept examined two raw gemstones from two different mines within the same region of Sri Lanka using SCOTTI.

- The two gemstones produced clearly distinguishable XFI spectra.
- Differences were detectable despite the very small quantities of relevant trace elements.
- The experiment demonstrated the potential of high-sensitivity XFI to distinguish between gemstone samples.
- The results represent an initial proof-of-concept, rather than a validated method for determining gemstone origin.

Implications for Gemstone Traceability

The proof-of-concept suggests that highly sensitive XFI could potentially provide an additional physical layer of evidence for gemstone traceability. If further research demonstrates that sufficiently consistent signatures can be associated with particular mines or geological environments, the approach could complement documentary and digital traceability systems.

However, the study is still at an early stage. The presentation identifies further measurements as the next step, meaning that considerably more samples and testing would be required before conclusions about reliable mine or geographic origin determination could be made.





Research Outlook

Further measurements and the expansion of gemstone datasets will help assess whether XFI signatures can reliably support gemstone provenance determination and traceability.

The Characterization of Gemstones and Gem-bearing Ore in Ratnapura District, Sri Lanka

Weeralal,J.L.S.G.,Premarathne,K.A.D.K., Piranavan, S,Samarasinghe, S.N.C.B., Samaradivakara, G.V.I., Premasiri, H.M.R.

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Sri Lanka, and specifically the Ratnapura District, has a rich, millennia-long history as a prolific source of diverse, high-quality precious and semi-precious gemstones, which are primarily deposited in secondary alluvial environments formed through extensive weathering and erosion. The unique geologic environments of these deposits greatly affect both the physical and chemical characteristics of the gems and the host ores. The global gem market has increasingly sought transparency in recent years, and the exact origin of a gemstone is an important factor for certification, valuation and to be ethical about the stone's origins. In Sri Lanka, the traditional knowledge, visual study and the subjective experience of the local miners and traders have been the only means to determine the localities from which these stones are deposited. This is an approach that has been used for centuries in this industry; however, it is not scientifically precise and reproducible. Thus, a transition to strong scientific methods is needed that are able to accurately describe and distinguish gemstones and related source gravels by reliable geochemical markers specific to localities of deposition. To meet this need, the present study has conducted a detailed geochemical study in ten active gem open-pit mine sites in the major gem producing region of the Ratnapura district. Field investigations involved taking samples of Green Zircon and Pink Sapphire of known color, and also semi-precious gem-bearing ores from the mines and the duly discarded gravel washing material. The faceted gemstones were first gemologically verified with a refractometer, and then by non-destructive surface elemental analysis (SEM-EDX) in order to identify variations in major and trace element composition. At the same time, a representative bulk sample of the gem bearing ores was crushed in Tema mill and the particles finer than 63 µm were separated by sieving and subjected to partial acid digestion (aqua-regia) according to the standard ISO 11466. The leachable fractions were then analyzed by Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES) for the presence of fifteen elements (seven major oxides and eight trace elements/rare-earth elements). Various chemical-distance matrices (Euclidean Distance) and statistical analytical methods such as Principal Component Analysis (PCA) were used to assess compositional gradients and possible correlations between the host ore chemistry and gemstones. SEM-EDX analysis showed that there were compositional gradients in the Green Zircon, with the impurities present varying from 4.5% to more than 12% and the Zr/Si atomic ratio was variable across the locality. Pink Sapphires were found to contain trace amounts of chromium and variable non-corundum impurities. In addition, ICP-OES of the gem-bearing ores showed some distinct mafic to ultramafic signatures (high Cr, V, Co) between localities, and a preliminary correlation between the iron in the zircon and the bulk ore Fe_2O_3. Signatures for provenance are quite clear in composition, but larger numbers of samples, complete ore digestion, and more sophisticated techniques for trace element analysis, such as LA-ICP-MS, will be required to establish definitive signatures.

Keywords: *Gemstone provenance, Geochemical characterization, Gem-bearing ore, SEM-EDX, ICP-OES*

Research at a Glance

Research Focus
Investigating whether the geochemical characteristics of gemstones and associated gem-bearing deposits vary between mining localities in Ratnapura District and could contribute to future approaches for gemstone provenance.

Study Area & Samples
Samples were collected from 10 active gem-mining sites across Ratnapura District (including Kiriella, Gileemale, Balangoda, Kalawana, Rakwana, Pelmadulla and Nivithigala), including green zircon, pink sapphire and associated gem-bearing material.

Methods

- Gemological identification:**SEM-EDX**
- Gemstone analysis · **ICP-OES**
- Analysis of gem-bearing material & chemical-distance analysis · **Principal Component Analysis (PCA)**

Key Findings

- Green zircon showed locality-related compositional variation, including differences in impurity levels and Zr/Si ratios.
- Pink sapphire samples showed variation in non-corundum impurities, although important diagnostic elements were below the sensitivity of SEM-EDX.
- Gem-bearing ores showed distinct geochemical variation, including Cr–V–Co signatures associated with mafic to ultramafic source material.

Current Limitation
The dataset does not yet allow the source of an individual gemstone to be determined, and SEM-EDX was insufficient for detecting some diagnostic trace elements in sapphire.

Research Outlook
Larger sample sets and more sensitive trace-element techniques are needed to determine whether robust locality-specific provenance signatures can be established.

Geotechnical Engineering Applications to Enhance Open-Pit Gem Mining Operations in Ratnapura District, Sri Lanka

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Ratnapura district in Sri Lanka has been famous across the world for high-quality gems found over the decades from alluvial deposits. The source of origin is considered as "Samanala" mountain complex from which four major rivers in the country originate. These alluvial deposits are found from shallow to deeper levels across the district. The traditional way of mining these deposits are by digging the pits for shallow alluvial deposits, and timber supported pits followed by cross-cuts for deeper deposits which are also supported by selected special timber varieties. Even though this process is a slow operation and less productive, it has been the choice of many miners and investors in the gem mining industry as per the needs in the past. Subsurface ventilation had been the most difficult they had faced and many deposits had been given up due to this practical difficulty. As per the needs of modern society, there is a new trend on starting large-scale open-pit mines. In this transition, the industry has faced a lot of practical problems due to not having a good focus on stability of earthen slopes. Hence, most of the sites experience even fatal accidents due to sudden collapse of earthen slopes. The current open-pit mining operations have not properly taken the inputs by the geotechnical engineering professionals to enhance the operational safety of the workers and the excavations. The main reason for these issues could be as most of the miners prefer to maintain the confidentiality of the resources on their sites, and hence visits by the outsiders are not entertained. This study is well focused to identify the operational safety issues related slope stability in open-pit gem mining, and the fieldwork covered visiting of ten active open-pit mining operations across Ratnapura district. The outcome of the study showed that most of the slopes on these sites are unstable, however that an optimised benched slope design that maintains an 1:2 ratio and bench heights of 3m to 5m can successfully attain a safe Factor of Safety greater than 1.25. Further, the proposed 'Divide and Stabilize' method has been adopted to successfully counterbalance lateral pressure and dewatering effects through the use of localized and reusable steel sheet piles and the progressive cut and fill sequence. Based on the outcome of this study, timber-shoring can be recommended for shallow open-pit mine operations as a low cost slope stability method for small–scale mines. However, for large-scale operations where the investors are concerned of high productivity, sheet piling is recommended as a reliable and safe earth supporting system. Application of piling for open-pit gem mining has another advantage of opening up the opportunity for the investors to exploit a maximum possible land volume, without leaving a huge space to maintain stability of unsupported earthen slopes. The rehabilitation together with pile supported excavations are recommended to enhance the quality of current mining practices in open-pit gem mines.

Keywords: *Alluvial deposits, Divide and stabilize, Gem mining, Geotechnical techniques, Slope stability*

Research at a Glance

Research Focus

Developing a safe and cost-effective geotechnical framework for open-pit gem mining in Ratnapura, addressing slope instability, groundwater, excavation design and support systems.

Study Area & Samples

Field investigations covered 10 active open-pit gem mines across Ratnapura District, representing different soil conditions, pit depths, groundwater challenges and mining practices.

Methods

- Field observations
- Soil and groundwater assessment
- Slope-stability analysis
- Evaluation of timber and sheet-pile support systems
- Engineering design of optimised slope geometries and staged excavation methods.

Key Findings

- Water saturation and steep or near-vertical pit walls were identified as major contributors to instability.
- Modelling indicated that a 1:2 benched slope with 3–5 m bench heights could achieve a Factor of Safety above 1.25 under the assessed conditions.
- Timber support was considered suitable primarily for shallow excavations, while sheet piling offers greater stability for deeper, waterlogged pits.

Current Limitation

Ground and groundwater conditions vary considerably between mining sites. The presentation identifies the reported soil parameters as preliminary design values, requiring site-specific geotechnical testing before final slope designs are implemented.

Research Outlook

Further development and field validation of the proposed “Divide and Stabilize” method, combining staged excavation, localized reusable sheet piling, progressive backfilling and rehabilitation, could support safer and more resource-efficient deep open-pit gem mining.

Influence of Locality on Colour Enhancement of Heat-Treated Milky Geuda from Sri Lanka; A Mineralogical and Geochemical Investigation

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Blue sapphire is one of the most important gemstones in Sri Lanka and has a high commercial value in the gem industry. Geuda is a low-grade variety of corundum that can be converted into blue sapphire through heat treatment. Nevertheless, Geuda from different localities exhibit variations in chemical composition, inclusions, and structural features, which may influence colour enhancement during heating. Therefore, this study investigated the effect of the locality of Milky Geuda on colour enhancement after heat treatment. A total of 53 Milky Geuda samples were collected from several gem-bearing regions in Sri Lanka including Kataragama, Ridiyagama and Bakamuna. The samples were analysed before and after heat treatment using optical microscope, UV-Visible spectroscopy, Fourier Transform Infrared (FTIR) spectroscopy, Raman spectroscopy, and X-ray Fluorescence (XRF) spectrometry. Visual observations revealed significant colour enhancement in most samples, while only a few showed slight changes. Transparency has been improved in all samples after heat treatment. Fractures and cracks have been increased due to the thermal expansion of inclusions. The highest number of fractures was observed in samples from Kataragama, whereas Ridiyagama samples showed the lowest occurrence. UV-Visible spectroscopy indicated that Bakamuna samples retained Fe^{3+} absorption peaks at 388 nm and 450 nm after heating, suggesting weaker blue colour development. FTIR analysis showed the presence of OH features before heating, which disappeared or changed after treatment. Raman spectroscopy demonstrated locality-dependent peak shifts, with the smallest shifts observed in Ridiyagama samples and the largest in Bakamuna samples. XRF analysis revealed that increased concentrations of iron and titanium, together with reduced aluminium content, enhanced blue colour development. Higher vanadium concentrations contributed to darker blue hues. The optimum elemental ratio for effective colour enhancement was identified as Ti:Fe:Al = 1:3:323.

Keywords: *Colour Enhancement, Corundum, Heat Treatment, Locality Effect, Milky Geuda*

Research at a Glance

Research Focus
Investigating how the locality of Milky Geuda influences colour enhancement during heat treatment, with a focus on mineralogical, chemical and spectroscopic differences between samples from different Sri Lankan gem-producing regions.

Study Area & Samples
A total of 53 Milky Geuda samples were collected from Kataragama, Ridiyagama and Bakamuna and analysed before and after heat treatment.

Methods

- Optical microscopy
- UV-Visible spectroscopy
- FTIR spectroscopy
- Raman spectroscopy
- XRF spectrometry
- Controlled heat treatment at 1,800°C for 60 minutes in a reducing atmosphere

Key Findings

- Most samples showed colour enhancement and improved clarity after heat treatment, but outcomes varied by locality.
- Bakamuna samples showed comparatively weaker blue colour development, while Ridiyagama samples came closest to the identified Ti:Fe:Al ratio of 1:3:323 associated in the study with effective colour enhancement.
- Higher vanadium concentrations were associated with darker blue hues.

Current Limitation
The study examined Milky Geuda from three localities under a specific heat-treatment regime. The results therefore establish locality-related patterns within the studied samples rather than a general predictive model for all Sri Lankan Geuda.

Research Outlook
Further research could build on the observed mineralogical, chemical and spectroscopic differences between localities to investigate relationships between corundum characteristics, geological origin and heat-treatment response.

FUTURE RESEARCH DISCUSSIONS



Listening to Biodiversity: A Proposed AI-Based Study of Bird and Frog Vocalisations in Gem-Mining Landscapes

Discussion with Prof. Sampath S. Seneviratne, University of Colombo

At the panel discussion, Prof. Sampath S. Seneviratne presented and discussed the proposed future research initiative "Listening to Biodiversity: An AI-Based Study of Bird and Frog Vocalisations in Gem-Mining Landscapes." The discussion explored how the sounds of birds, frogs and other wildlife could provide a new way of understanding the ecological health of landscapes affected by gemstone mining. Rather than relying solely on conventional biodiversity surveys, the proposed approach would use passive acoustic monitoring to repeatedly "listen" to ecosystems, generating environmental recordings that can be analysed with AI-supported tools such as BirdNET and complemented by expert validation. The broader concept envisages monitoring not only birds and frogs, but potentially bats, insects and overall soundscape characteristics.

The discussion also considered how this approach could be transferred from agricultural and agroforestry landscapes to Sri Lanka's gemstone-producing regions. A future study could compare active mining sites, recently closed or rehabilitated mines, relatively undisturbed reference sites, restoration areas and agricultural landscapes, creating a gradient through which ecological disturbance and recovery can be studied over time. This is particularly relevant because, while artisanal and small-scale gemstone mining can create localised impacts on soils, waterways and habitats, there remains comparatively little longitudinal evidence showing how biodiversity changes during mining and how ecosystems recover following rehabilitation.

Looking beyond an initial research project, the discussion raised the possibility of establishing a long-term biodiversity monitoring platform for Sri Lanka's gem-mining landscapes. Acoustic recordings could be combined with ecological observations, land-use information, mining and rehabilitation data and other environmental indicators to measure change over several years. The aim would therefore not simply be to determine whether an individual mine can be described as "sustainable," but to generate measurable evidence of what happens to biodiversity before, during and after mining, how quickly ecosystems recover, and which rehabilitation practices lead to stronger ecological outcomes.

The proposed research could ultimately form the first work stream of Biodiversity Observatory for Gem-Mining Landscapes, envisioned as a longer-term research infrastructure extending toward 2030 and beyond. An initial 24-month phase could establish a network of approximately 16 passive acoustic monitoring stations, baseline datasets across different landscape types, AI-supported species-identification workflows and a standardised biodiversity-monitoring protocol for gemstone-mining landscapes. Importantly, the initiative is conceived as a collaborative research platform, bringing together expertise in biodiversity science, conservation, mining, geology, AI, acoustic ecology, environmental policy and ecological restoration, with AI supporting, rather than replacing, scientific and expert assessment.

Summary
The *Listening to Biodiversity* proposal explores how AI-supported acoustic monitoring of bird and frog sounds could provide a novel scientific method for assessing biodiversity impacts and ecological recovery in Sri Lanka's gemstone-mining landscapes.

Architecture of Transparency: Power and Evidence Control in Informal Sri Lankan Gemstone Supply Chains

Discussion with Researcher Isabel Henning,University of Hamburg,

Field Work - Sri Lanka (September 2026)

During her research stay in Sri Lanka, Isabel Henning from the University of Hamburg explored an often-overlooked dimension of gemstone traceability: who controls information, evidence and origin claims along the gemstone supply chain, and how this relates to economic power and value creation. Sri Lanka offers a particularly revealing setting, combining centuries-old gemstone trading traditions and relationship-based networks with growing international demands for transparency, responsible sourcing and verifiable origin. Stones may pass through miners, mine owners, brokers, traders, cutters, dealers and exporters, while much of the exchange continues to rely on reputation, verbal agreements and tacit knowledge rather than formal documentation. This tension between established, trust-based practices and emerging expectations for documented evidence lies at the heart of her research.

From the mine to the international markets

During four weeks of fieldwork, Isabel Henning followed different stages of the value chain through visits and conversations in Meetiyagoda, Beruwala, Ratnapura and Colombo. Her qualitative approach combines stakeholder and value-chain mapping, semi-structured interviews and participant observation with miners, traders, cutters, brokers, exporters and other industry actors. Rather than simply tracing the physical journey of a gemstone, the research asks who has access to the stone, who possesses information about its history, who can document that information and whose evidence is ultimately considered credible. Local knowledge about origin may exist without formal records, while actors able to translate that knowledge into certificates, documentation or internationally accepted claims can gain significant influence.

Transparency is also about power

A central concept is 'evidence control'. Isabel Henning's work examines the social and economic structures behind transparency systems. Who decides what counts as credible evidence? Who has the resources and knowledge to produce it? Who controls origin narratives? And what happens when formal transparency requirements encounter supply chains built around interpersonal trust and informal institutions?

Why this matters for responsible gemstone supply chains

The research suggests that traceability, certification and digital technologies cannot be introduced effectively without understanding existing relationships, incentives and power structures. Effective traceability is therefore not only about collecting more data. It is also about understanding who produces that data, who controls it, who benefits from making it visible and whose knowledge may otherwise remain excluded. By connecting global value-chain research with the realities of artisanal and small-scale mining and informal gemstone trading, the Master's thesis aims to inform traceability approaches that are technologically credible while remaining locally grounded, inclusive and responsive to the people who make the gemstone supply chain function.

Summary

Isabel Henning's research explores how information, evidence control and power dynamics shape gemstone traceability in Sri Lanka.

Digital Product Passports and the Future of Sri Lankan Gemstones: From Provenance to Ethical Luxury

Industry Conversation & Demonstration with Vandana Hettiaratchi, Gem Trail Lab

During the industry discussion, Vandana Hettiaratchi presented Gem Trail Lab's vision for transforming Sri Lanka's gemstone industry through technology, research and responsible sourcing. The conversation explored how Digital Product Passports (DPPs) can improve transparency and traceability by documenting a gemstone's journey from mine to market, bringing together information on origin, mining practices, verification, certification and environmental and social responsibility.

The discussion also addressed the importance of developing credible verification and certification frameworks that recognise responsible practices in artisanal and small-scale mining. Rather than focusing solely on gemstone origin, the proposed approach aims to make environmental and social performance more visible, helping miners and businesses demonstrate their efforts while building greater trust among international buyers and consumers.

Particular attention was given to the European Union's Empowering Consumers for the Green Transition Directive (EmpCo) and its implications for sustainability communication. As the EU strengthens requirements around environmental claims, businesses will increasingly need credible, verifiable evidence to support statements about sustainability and responsible sourcing. For the gemstone industry, this highlights the importance of moving beyond general claims towards documented practices, transparent methodologies and independent verification. Digital Product Passports could play an important role in organising and communicating such evidence, helping businesses substantiate their claims while reducing the risks of greenwashing and greenhushing.

The conversation further introduced MADE by Gem Trails™, an AI-powered B2B jewellery commissioning platform designed to connect international buyers with vetted local artisans and small-scale jewellery producers in Sri Lanka. By combining AI-supported jewellery design and commissioning with responsibly sourced gemstones and local craftsmanship, MADE™ aims to create new market opportunities for smaller producers who often lack direct access to international clients. The initiative seeks to strengthen local value creation, support responsible sourcing and demonstrate how technology can connect Sri Lanka's artisanal jewellery sector with global markets.

Looking ahead, the discussion highlighted the potential for Sri Lanka to position itself as a leader in responsibly sourced coloured gemstones.

Summary
Vandana Hettiaratchi presented Gem Trail Lab's vision for transforming the gemstone industry through Digital Product Passports, credible sustainability verification and certification, and AI-powered solutions that strengthen traceability, responsible sourcing and market access.

CURRENT STATE & FUTURE OF SRI LANKA'S GEM INDUSTRY

The Expert Industry Panel brought together leaders from Sri Lanka's innovation ecosystem, regional entrepreneurship initiatives and academia to explore how the country can translate its gemstone heritage into greater economic and social value.

Panelists



Heminda Jayaweera
Managing Director
TRACE Expert City



Visaka Ellawala
Founder
Nalanda Innovation Hub



Emeritus Prof. P. G. R. Dharmaratne
University of Moratuwa

The Central Challenge

Sri Lanka is a globally recognised source of gemstones, yet much of the downstream value is created elsewhere. Informal industry structures, limited technology adoption and unequal market access constrain opportunities in mining communities. A central theme of the discussion was the significant gap between Sri Lanka's rich gemstone resources and the economic value retained within the country, particularly in traditional mining regions such as Ratnapura. Despite its longstanding reputation as a leading source of high-quality gemstones, Sri Lanka continues to face challenges related to informal industry structures, limited technological adoption, insufficient local value addition, and unequal access to economic opportunities.

THREE PRIORITIES FOR INDUSTRY TRANSFORMATION
Innovation and local value creation • Community empowerment • Research and international competitiveness

Innovation and Local Value Creation

Heminda Jayaweera highlighted the potential for technological innovation and entrepreneurship to transform the sector. Drawing on TRACE Expert City's mission to strengthen Sri Lanka's innovation economy, he emphasised the need to move beyond traditional gemstone exports towards a more diversified industry encompassing jewellery manufacturing, digital solutions, artificial intelligence, machinery development, and STEAM-related innovation. He also noted the importance of fostering a stronger startup ecosystem and supporting bottom-up innovation.

Community Empowerment and Inclusive Development

Visaka Ellawala drew attention to the economic inequalities experienced by gemstone-producing communities. Although gemstones worth up to an estimated LKR 1 billion are extracted daily, according to figures cited during the discussion, much of the resulting economic value does not remain in Ratnapura. Through Nalanda Innovation Hub, she advocates for greater participation by local entrepreneurs, artisans, young people, and particularly women in shaping the industry's future. Her vision includes exploring digital platforms that could facilitate more transparent and direct international trade in rough gemstones, potentially improving market access and economic opportunities for artisanal and small-scale miners.

Research, Policy and International Competitiveness

Emeritus Professor P. G. R. Dharmaratne reflected on Sri Lanka's longstanding gemstone heritage and the need for stronger integration of scientific research, transparent governance, and evidence-based policymaking. Drawing on his experience as former Chairman of the National Gem and Jewellery Authority, he highlighted the importance of learning from international competitors such as Thailand, which has successfully developed into a major gemstone trading centre despite limited domestic mining activity.

A Shared Vision for the Future

Across the discussion, a common vision emerged: Sri Lanka's gemstone industry must evolve from a predominantly resource-driven sector towards a more innovative, transparent, inclusive, and value-generating industry. Achieving this transformation will require closer collaboration between academia, industry, technology innovators, policymakers, and local mining communities. Particular emphasis was placed on ensuring that the benefits of innovation reach the people and regions where gemstones originate. The panel reinforced that Sri Lanka's greatest opportunity lies not only in the gemstones it extracts, but in the knowledge, technologies, entrepreneurship, and local capabilities it develops around them.

EMERGING THEMES & RESEARCH PRIORITIES

Across the keynotes, research presentations, industry discussions and post-event surveys, several interconnected themes emerged. While the symposium addressed different aspects of the gemstone sector, from geological analysis and mining engineering to biodiversity, traceability and market development, a common priority was evident: bridging scientific research, technological innovation and industry practice to support a more responsible and competitive gemstone sector. The following priorities represent a synthesis of the symposium discussions and potential directions for future research and collaboration.

1. Advancing Scientific Gemstone Provenance

Research into geochemical signatures and advanced analytical technologies, including X-ray Fluorescence Imaging (XFI), demonstrated promising approaches to investigating gemstone origin. However, establishing reliable mine- or locality-specific provenance will require larger datasets, improved analytical methods and further validation.

2. Improving Mining Safety and Environmental Responsibility

Research on open-pit mining highlighted the importance of geotechnical engineering for improving worker safety and excavation stability. Future work could explore practical, affordable solutions for artisanal and small-scale miners, alongside improved rehabilitation practices and environmental management.

3. Measuring Biodiversity and Ecological Recovery

Proposed AI-supported acoustic monitoring offers opportunities to investigate biodiversity across active, abandoned and rehabilitated mining landscapes. Developing long-term environmental datasets could strengthen understanding of mining impacts and provide evidence for more effective restoration.

4. Building Credible and Inclusive Traceability Systems

Digital traceability alone cannot guarantee the accuracy of origin or sustainability claims. Combining scientific verification, documented supply-chain information and an understanding of informal trading relationships could support more credible systems while ensuring that miners and smaller businesses are not excluded.

5. Strengthening Local Value Creation and Competitiveness

The symposium highlighted opportunities for Sri Lanka to move beyond gemstone extraction towards greater domestic processing, technological innovation, entrepreneurship and international market participation. Research and innovation should contribute not only to stronger industry competitiveness but also to greater recognition and economic opportunities for gemstone-producing communities.

Progress across these areas will depend on stronger collaboration between universities, industry stakeholders, technology developers, policymakers and mining communities. Connecting research with practical field applications, accessible technologies and local knowledge will be essential to translating emerging ideas into measurable improvements.



LOOKING AHEAD

The 1st International Sustainable Gem Research Symposium marked an important step towards connecting scientific research, technological innovation and responsible industry development in Sri Lanka's gemstone sector.

The discussions demonstrated both the opportunities and the challenges ahead. From emerging technologies for gemstone provenance to safer mining practices, biodiversity monitoring and more inclusive value chains, meaningful progress will require continued research, practical experimentation and collaboration across disciplines.

For Gem Trail Lab, the symposium represents the beginning of a longer-term effort to build bridges between academia, industry and gemstone-producing communities. Building on the connections established in Colombo, the aim is to encourage further research partnerships, support field-based studies and explore how scientific knowledge and digital technologies can translate into practical benefits for artisanal and small-scale miners.

The future of Sri Lanka's gemstone industry will depend not only on the resources beneath its soil, but also on the knowledge, innovation and opportunities developed around them.



Manuel Kreitmeir, CEO Gem Trail Lab

The conversation started in Colombo. The next step is turning research and dialogue into action.

ACKNOWLEDGEMENTS

Gem Trail Lab would like to sincerely thank everyone who contributed to and attended the 1st international Sustainable Gem Research Symposium on 22 September 2026. We are especially grateful to all participants who took the time to join us, both in person and online, and made the symposium such a meaningful exchange of ideas.

A special thank you goes to **Heminda Jayaweera** and the entire **TRACE Expert City** team for hosting and supporting the event, and to the wonderful volunteers from **The Generation Alpha** organisation, whose help with logistics and coordination made the day possible.

We would like to express our deepest gratitude to **Emeritus Professor P. G. R. Dharmaratne**, whose academic guidance, encouragement and belief in this initiative from the very beginning have been instrumental in bringing the symposium to life. We are equally grateful to **Professor H. M. R. Premasiri** and **Dr. G. V. I. Samaradivakara** from the University of Moratuwa for their continued support, dedication and invaluable contributions to our research collaborations.

Our heartfelt thanks also go to our keynote speakers, researchers, students and contributors from the University of Hamburg, University of Moratuwa, University of Colombo and Uva Wellassa University. In particular, we thank **Professor Laura Marie Edinger-Schons, Professor Florian Grüner, Professor Sampath S. Seneviratne, Chamal Jaliya, Isabel Henning** and **Visaka Ellawala** for sharing their knowledge, perspectives and enthusiasm.

Finally, a special thank you to the **National Gem and Jewellery Authority (NGJA)**, Sri Lankan authorities, miners, mine owners, gemstone traders, artisans and local communities for their continued support, openness and willingness to share their knowledge and experiences. Their trust and collaboration make our research possible, and they remain at the heart of everything we hope to achieve.



Session with Prof. Laura Schons



Session with Isabel Henning



Panel Discussion



Panel Discussion



Audience & Hall



Opening Remarks - Heminda Jayaweera



Vote of Thanks - Emeritus Prof. Dharmaratne



Session with University of Moratuwa



Demonstration by Gem Trail Lab



Audience & Hall



Audience & Hall



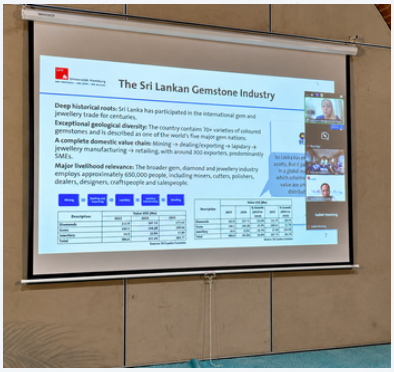
Session - Prof. Sampath Seneviratne



Audience & Hall



Audience Q&A



Online session - University of Hamburg



Streaming Services



Audience & Hall



Keynote - Emeritus Prof. Dharmaratne



Session - Prof. Sampath Seneviratne



Conversation with Gem Trail Lab



Audience



> Beyond the gemstone lies a story of science, people, nature and opportunity. Understanding that story is where a more sustainable gemstone industry begins.

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