

Application of modern pumpable polyester resin to the mining cycle

T Roberts *Jennmar, USA*

D Faulkner *Jennmar, USA*

R Koekemoer *Komatsu, Canada*

Abstract

The use of pumpable polyester resin has become an increasingly popular choice for ground support in underground hard rock mining. Its ability to effectively reinforce and stabilise the surrounding rock mass with reduced quality control issues has turned it into a preferred product for rapid development in difficult ground and collapsing drill holes. One of the key advantages of pumpable polyester resin is its versatility. When used in a variety of ground conditions, including fractured rock, corrosive conditions, and high-stress environments, polyester resin injection is an ideal solution for many mining applications.

Originally developed for use with hollow bar on mechanised bolters, pumpable polyester resin has evolved over the years with significant advancements in resin formulation, application equipment and installation techniques. Today, applying modern pumpable polyester resin remedies inefficient ground support processes.

Efforts in the polyester resin systems development is increasing efficiency, designing applicable ground support, mitigating risk, reducing unplanned rehabilitation, improving quality control, limiting manual operator inputs, and integrating automated equipment and controls. This focus is making the application more consistent, which increases safety and productivity for the underground workforce.

This paper will discuss the purpose of using polyester-type resin, new developments, quality control and efficiencies of the modern polyester resin system integrated onto rebar bolters, cable bolters and jumbo drills in the mining process.

Keywords: *pumpable polyester resin, efficiency, quality control, productivity*

1 Introduction

A significant push for mining operators and contractors to achieve improvements in safety performance and development efficiency is driving a shift from traditional rockbolting products and installation methods to advanced automated resin-injected rock reinforcement systems. In underground mining, many operations are mining through intense faulting and alteration, especially around major structure and lithology contacts, resulting in poor rock mass quality and unstable rock in mine openings (Watt et al. 2018). This can result in personnel injury/fatality, equipment damage and production interruption. To stabilise the excavated opening, the rock mass is typically supported immediately after excavation by installing rockbolts that are either mechanical/friction-anchored or grouted using resin/cement cartridges or cement grout.

Over the last several decades, the resin-assisted rockbolting system has gained wide acceptance in the mining and civil industry due to its quick setting time, reliable anchorage, low cost, and other outstanding features such as durability, corrosion protection, shear resistance and sealing of fractures. However, insertion of a polyester resin cartridge tends to be difficult in poor ground, high openings and/or for long tendon installation. Some operators pneumatically shoot polyester resin cartridges into bolt holes but broken ground, collapsed drill holes and irregularly shaped holes can burst a standard cartridge when fired into drill holes. To date, the method of installing resin capsules is using a polymer tube and adaptor mounted to a jumbo drill is most common. Using the drill boom, insertion of the resin capsule is completed with a

cap/parachute attached to fix the capsule. The boom is then withdrawn along with the polymer tube from the drillhole, leaving the resin capsule installed into the drillhole. This method of installation is susceptible to the same issues encountered when shooting resin capsules, where the polymer tube has difficulty being inserted into the drillhole in poor ground and collapsed drill holes, generally breaking or damaging the polymer tubes and resin capsule/cap assembly (Roberts et al. 2019).

To overcome difficulties installing rock reinforcement in poor ground and collapsing drill holes, many operations now use hybrid friction bolts. These bolts are installed more easily in poorer ground and increase installed capacity but are still susceptible to corrosion and remain reliant on friction as the mechanical interface between the rock and bolt.

When anchoring cable bolts into drill holes, utilising mechanised cable bolting machines is a proven and successful process for installing 15.2 and 17.8 mm, seven-wire cable strand. Cable bolting machines traditionally use cement grout to secure the cable bolt into the drillhole. Cement grout is a very effective anchorage material although curing times associated with cement typically necessitate long cure times and re-entry times of 12–24 hours. The long cure times associated with cement grout significantly affect heading turnover in single-entry development, mines with limited available headings, and fast re-entry when rehabilitating main haulage and travel roads.

To improve bolting installation practices and installed rock reinforcement performance, and to meet the requirements of advanced mining company safety and efficiency expectation, the following systems were developed:

- Mechanised bolting machine utilising a carousel of self-drilling anchors, J-Lok P polyester resin injection and nut tensioning through a boom indexing system.
- Mechanised bolting machine utilising a carousel of torque tension rebar/threadbar resin bolts, J-Wand polyester resin injection and nut tensioning through an indexing system.
- Fully integrated J-Lok P polyester resin injection on a Komatsu mechanised bolting machine.
- Platform bolter conversion.
- Twin-boom jumbo bolter with split-feed booms and J-Lok P polyester resin injection using various self-drilling anchor designs.
- Mechanised cable bolting machine utilising original equipment manufacturers (OEM) standard nylon grout tubes and J-Lok P polyester resin injection.

This paper will detail the development of a polyester resin injection for various rock and cable bolting applications, rock reinforcement design to support polyester resin injection, and comparisons of the performance of polyester and urea silicate resins in terms of material properties and application.

2 Comparison of resin chemistry

2.1 The J-Lok P polyester resin

Polyester resins are the most widely used resin systems in different industries due to material availability, ease of use, low cost and excellent material properties. The operating service temperatures for polyester resins are wider than for other resin systems. Polyester resins are versatile because of their capacity to be modified or tailored during the manufacturing of the polymer chains. The principal advantage of polyester resins is a balance of properties (including mechanical, chemical and electrical), stability, lower cost and ease of handling or processing. For these reasons, Jennmar chose polyester resin for bolting injection applications.

The temperature effect on Part A and B of J-Lok P polyester resin appears to be relatively less significant. In cold weather, the resin and catalyst may be frozen. However, the low temperature will not affect the quality of the product and their functionalities remain the same once thawed. If ambient temperature is higher in summertime, viscosity of the J-Lok P Part A and B may drop slightly and sometimes filler particles

may settle at the bottom of the intermediate bulk container (IBC). The quality of the resin and catalyst remains the same and minor solid–liquid separation is rectified by remixing resin in the IBC. If stored correctly, the shelf life of polyester J-Lok P resin in IBCs should exceed two years. However, it should only be used beyond the manufacturer’s recommended date after passing laboratory testing.

2.2 Urea silicate resin

The chemistry of urea silicate resin is relatively more complicated. Part of the isocyanate in the B component undergoes a reaction with the water contained in the A component (an aqueous sodium silicate solution) and produces polyurea. The byproduct of carbon dioxide is scavenged by the sodium hydroxide-forming soda and simultaneously causes the precipitation of silicon dioxide. The other part of the isocyanate reacts with the di-isocyanate, producing poly-isocyanate. So both the silicate and isocyanate form separate polymer networks which penetrate each other and may form a chemical bond between isocyanate and silicate. Typically, the formation of a homogenous product requires a thorough mixing of the components in order to obtain an emulsion of the sodium silicate in the isocyanate component (Stankus & Ma 2018).

Chemically, temperature (air and rock) has a significant effect on the polymerisation reaction rate of any resin. The lower the temperature, the slower the reaction rate, and vice versa. Chemical reactivity of the urea silicate resins is very sensitive to temperature, as experienced by many mining operations that use urea silicate. With a 40°C underground air and product temperature, and large hole size, excessive pump pressure can be experienced, causing faster setting times and operational issues.

2.3 Mechanical strength comparisons

Usually the modulus of elasticity, compressive strength, shear strength and adhesive strength of cured chemical grouts are considered as the most decisive engineering properties in rockbolting applications.

To accurately evaluate the unconfined compressive strength and stiffness of J-Lok P polyester and urea silicate resin, comparative laboratory tests were conducted per ASTM D790-02 (ASTM International 2002). A 2:1 height-to-diameter ratio using a 2:1 resin/catalyst J-Lok P and Part A: Part B 1:1 urea silicate mixing ratio resin was prepared and cured for 24 hours. Shown in Figures 1 and 2 are urea silicate grout and J-Lok P samples after the tests. Figure 3 shows a comparison of stress versus deformation of both samples. The test results indicate that unconfined compressive strength and stiffness of the J-Lok P polyester resin are significantly higher than those of urea silicate.



Figure 1 Urea silicate samples after test



Figure 2 J-Lok P 2:1 ratio samples after test

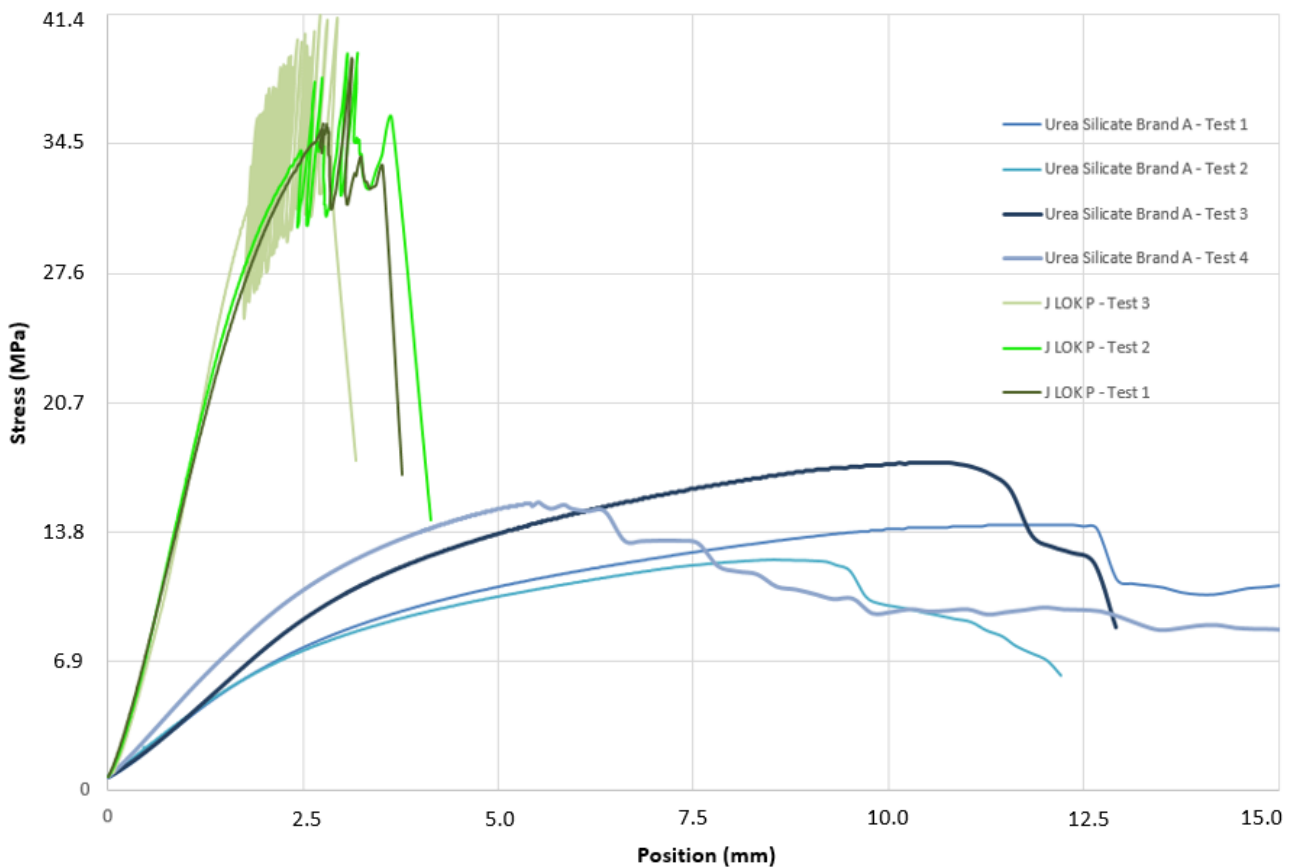


Figure 3 Unconfined compression tests; J-Lok P and urea silicate

The direct result is a higher-strength resin grout with reliable anchorage and higher installed capacity. Experience in underground mining has shown that other decisive characteristics which support the use of polyester resin are lower manufacturing cost, less brittleness, ease of handling and storage, longer shelf life, no isocyanate, a large control range of resin set times and applications suitable for varying underground temperature.

3 The J-Lok P system

The J-Lok P system is a specialised patented (patent number US 10,253,628 B2) hydraulic, pneumatic or programmable logic controller (PLC) controlled pumping system. It comprises three main components: a high-volume resin transfer station, an on-board resin storage station and an injection module. Depending on the application and project requirements, system designs are modified to meet resin ratio, on-board resin storage volume, and carrier size and injection volume requirements (Faulkner et al. 2017). Polyester resin and catalyst transfer from bulk mobile handling systems (Figure 4) to on-board resin is completed in approximately five minutes, assuming two 130 L tanks are filled.



Figure 4 Mobile polyester resin transfer stations used to pump resin and catalyst to machine-mounted resin storage. Resin transfer is predominantly completed at the start of a shift

On-board resin and catalyst storage capacity varies depending on the application. Cable bolters with a large carrier size and high resin consumption require large capacity whereas small bolting machines can only store small volumes due to limited space and carrier tramping loads, as shown in Figure 5. Hoses with camlock fittings connect quickly between both transfer and mobile stations.



Figure 5 On-board polyester resin and catalyst tanks to support mobile resin injection

The injection module shown in Figure 6 consists of two high-pressure bulk pumps that can maintain a consistent specified pumping ratio of the two-component resin. The injection module is operated manually or automatically from the safety of the machine's cab. The system is completely sealed and material kept separated until the injection point, requiring only minimal clean-up at the end of a shift.

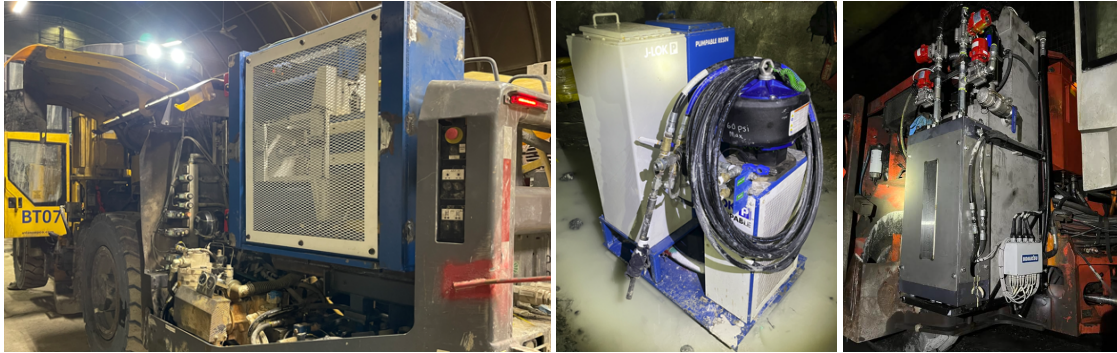


Figure 6 On-board high-pressure bulk transfer pumps. Shown are high-volume, multiple-shot mobile air-operated skid and single-shot pump options

J-Lok P mixed polyester resin uses water to flush the injection heads, a significant advantage for any mining operator. Unlike silicates, they require oil to flush and clean their injection heads. All J-Lok P resin injection systems are designed with integrated water flushing ports, located behind the resin and catalyst entry points to ensure thorough chemical flushing internally of the injection head.

3.1 J-Lok P system advantages

The advantages of employing the J-Lok P system, particularly in poor ground when using engineered solutions, are:

- Improved quality control by reducing manual operator inputs.
- An installed single-pass system designed to meet corrosion, dynamic and static requirements.
- Designed ground support that economically mitigates risk with minimal future unplanned rehabilitation.
- Products are designed using industry best practice and innovative methods.
- A fit-for-purpose system that meets life of mine and design requirements.
- Developed to be miner proof.
- Utilises many current industry installation practices and machines to reduce unplanned disruption to the mining cycle.
- Training, support and monitoring packages are tailored for operational requirements.

The opportunity to install a first-pass, high-capacity, corrosion-resistant, fully encapsulated dynamic rock reinforcement system is a significant advantage for any operator seeking improvements in safety, installation quality and efficiency. These advantages can be transferred to the majority of OEM drilling equipment in the market utilising conversion kits based on mine requirements. Installed bolt examples are shown in Figure 7.



Figure 7 Polyethylene-coated dynamic MPA and Falcon Bolts installed and grouted with polyester resin. The system provides full encapsulation with a high-strength grout, packing resin behind the plate and between the nut, which are common bolt corrosion locations

4 Mechanised bolting using self-drilling anchors

The use of single-pass drill, install and inject self-drilling anchors (SDA) significantly decreases the installation time of rockbolts in poor ground when compared to traditional methods. Use of the J-Lok P system also delivers the following benefits:

- No need to clear rock or debris in collapsed drill holes when using resin insertion tubes or pneumatically firing resin capsules.
- Encapsulation issues are eliminated when using pumpable resin.
- Homogenous resin mixing is achieved utilising engineered solutions rather than relying on operators to mix resin capsules with poorly designed resin rockbolts.
- Resin set time is customisable to suit rock temperature, pump speeds and varying bolt lengths.
- Operators are removed from the high-risk zone. Drilling, bolting, resin injection and nut tensioning are completed from within the cab of the drill.
- No boom movement is required to complete the rockbolt installation once drilling starts.

The J-Lok P system is supplied as a bolt-on assembly to OEM rockbolting equipment, as shown mounted to a Boltec machine in Figure 8. The J-Lok P system utilises on-board hydraulic and 24 V power supply and a system-specific PLC for system operation.

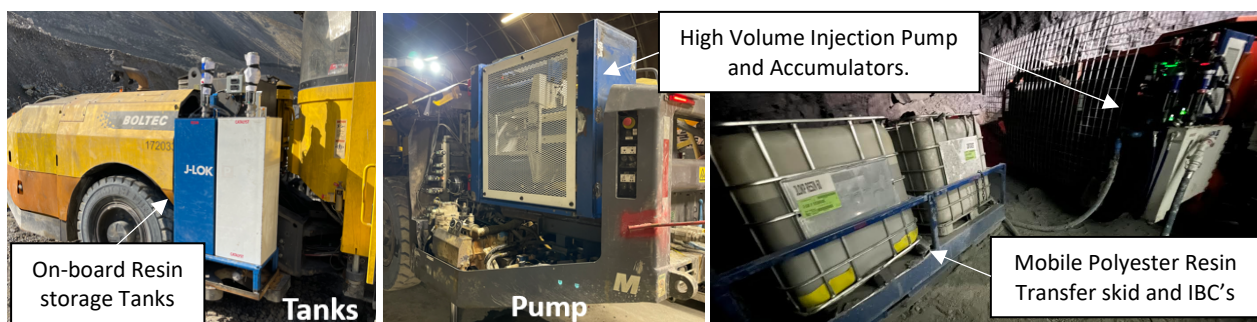


Figure 8 J-Lok P installation onto Epiroc M class Boltec. Resin and catalyst load cylinders are mounted on the side of the Boltec, and injection cylinders and 300 L accumulators are mounted on the side of the Boltec

To allow for seamless installation of an SDA bolt, modifications to installation sequences and tools are required. A female drifter shank and 46AF installation socket are installed onto the drill as shown in Figure 9. They complete drilling of the SDA bolts, removal of the shank from the bolt and tensioning of the nut.

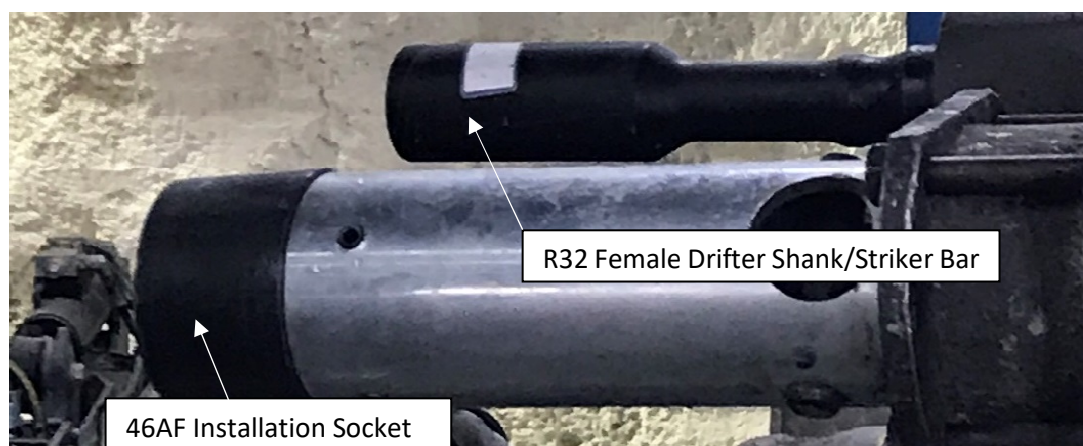


Figure 9 R32 female drifter shank and 46AF installation socket indexing into position when required to complete their respective processes

Injected resin and catalyst are pumped through reinforced hoses connected to the injection head assembly. The injection head assembly shown in Figure 10 is attached to a hydraulic cylinder that, when pushed onto the end of the installed bolt, seals the injection nozzle against the end surface of the bolt, allowing the polyester resin and catalyst to be injected into the bolt.

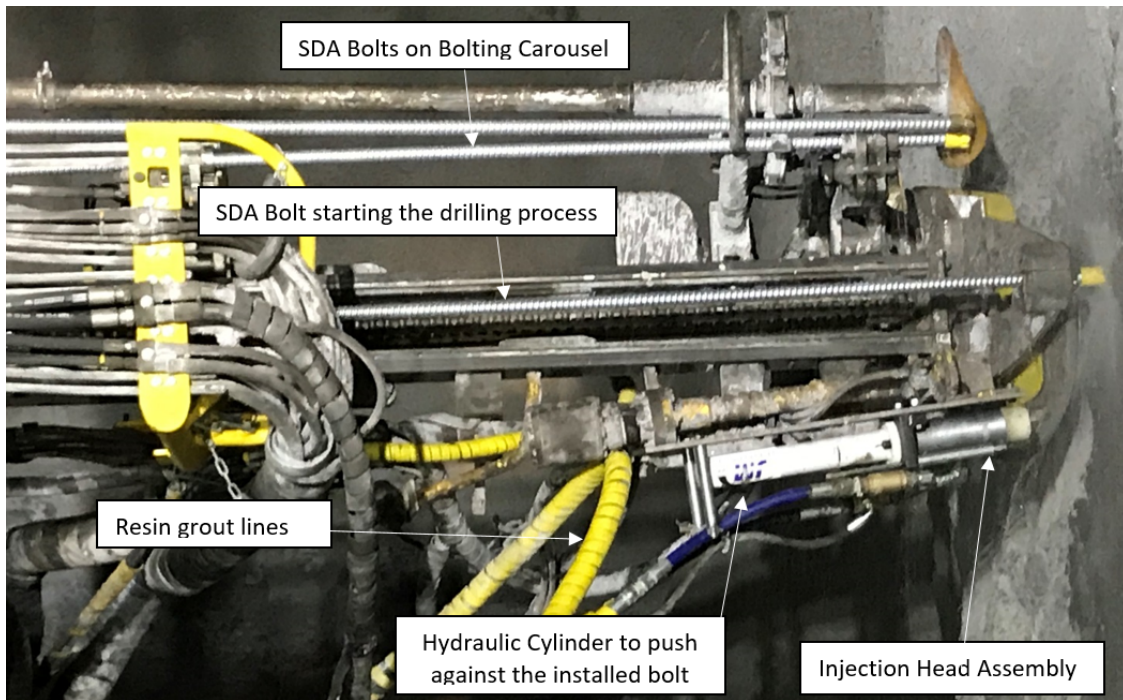


Figure 10 The Boltec mechanical bolting unit with the injection head assembly located in place of the resin cartridge injection nozzle and cartridge supply hose

To date, there are now many J-Lok P polyester resin injection systems mounted to various OEM bolters completing SDA or dynamic MPA fully encapsulated rock reinforcement.

5 Mechanised bolting using resin rebar/threadbar bolts

To support the installation of industry-standard torque tension, headed resin rebar and threadbar bolts such as the J-Tech bolt, the Jennmar J-Wand system was developed to support resin injection and more traditional bolting practices. The J-Wand system can be mounted on bolting carousels or jumbo booms. The J-Wand system is predominantly designed for bolting carousels, completing installations in a three-part process. The first phase requires drilling the hole using a drill steel and 35–37 mm drill bit. The second phase involves indexing the J-Wand into position, feeding the injection tube into the drillhole and injecting an unmixed resin and catalyst whilst withdrawing the tube from the drillhole. Phase three requires indexing to the bolting position. The bolt installation requires maximum drill revolutions per minute and a steady feed rate, mixing the resin and catalyst with a steady feed rate. Figure 11 shows the three positions of the installation process.

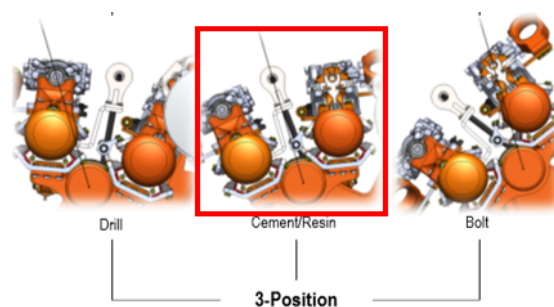


Figure 11 J-Wand system and Komatsu carousel showing the drilling, resin grouting and bolting position steps

The J-Wand system was developed to be mounted on all OEM bolting carousels with Komatsu and Sandvik assemblies, as shown in Figure 12. Each J-Wand is supplied as a conversion kit to allow mounting onto various OEM models.

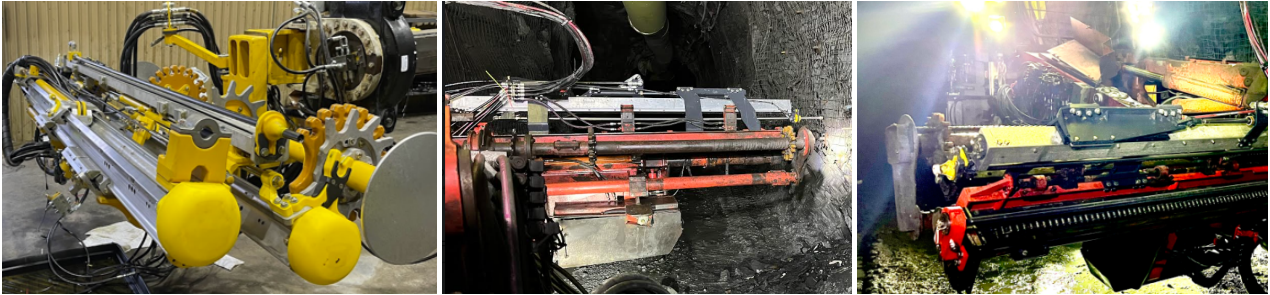


Figure 12 J-Wand system mounted onto Komatsu and Sandvik bolting booms

Once installed and operational, the system allows a steady feed rate of insertion and withdrawal to ensure resin and catalyst are pumped into the drillhole evenly along the drillhole column. Its operation is shown in Figures 13 and 14. Developed to work with the viscosity of the J-Lok P system, resin retains stability when unmixed resin and catalyst is pumped into vertical drill holes prior to resin bolt insertion and mixing.

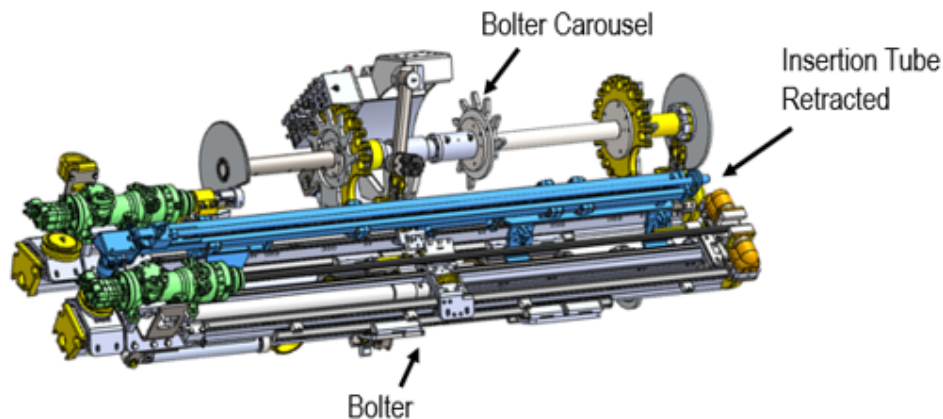


Figure 13 J-Wand system illustrated in blue is mounted onto a Komatsu carousel in a retracted position

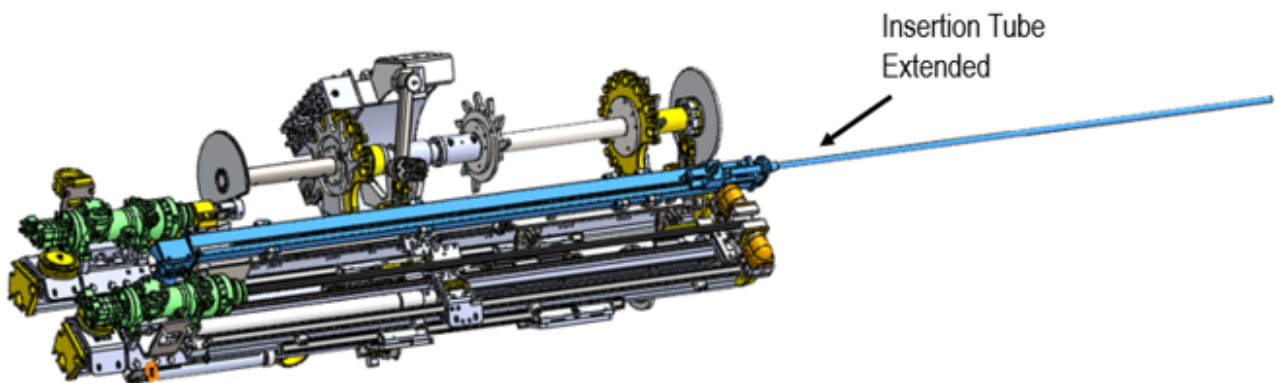


Figure 14 J-Wand system illustrated blue is mounted onto a Komatsu carousel in an extended position

After resin injection, resin bolts are inserted into the drillhole. Rotation is applied at maximum drill revolutions (approximately 200 RPM) to ensure homogenous resin mixing and a steady feed rate of mix through the injected resin column. If utilising a torque tension bolt, the nut is tensioned after the resin is cured, requiring pin breakout. This secures the nut against the face of the rockbolt plate. Rockbolt tensioning is completed when the drifter motor stalls out (approximately 450 Nm).

6 Fully integrated Komatsu bolter with polyester resin injection

Jenmar and Komatsu have collaborated to provide full OEM conversion kits and J-Lok P integrated polyester resin injection onto Komatsu mechanised bolting and jumbo machines (see Figures 5 and 15). The Komatsu ZB21 model shown in Figure 16 is the smallest machine in the Komatsu fleet. Having the ability to miniaturise the J-Lok P system, and successfully mount and operate it while remaining within carrier design limits is a significant benefit for operations mining small development drives.

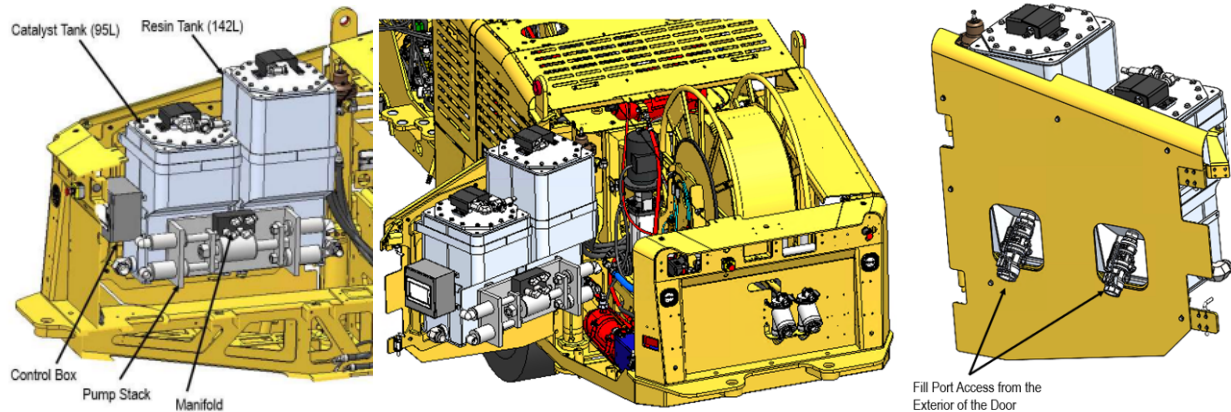


Figure 15 Fully integrated J-Lok P system illustrated on a Komatsu ZB/J21 bolting or jumbo machine

The Komatsu integration utilises a 2:1 ratio tank and injection system mounted inside the machine body. The design allows for easy access and function allows for simple maintenance as it is mounted on a hinged door.

The Komatsu ZB21 has many design benefits to support efficient bolting practices. These include:

- Utilising highly efficient Montabert drifters to improve penetration rates and drilling time.
- Single carrier used across bolter and jumbo machines.
- Integrated control systems for all machine operations, including J-Lok P resin injection.
- Patented screen-handling system.
- Patented flexible bolt centraliser.



Figure 16 Komatsu ZB21 bolting machine with J-Lok P injection head assembly mounted to the carousel

Utilising the proven J-Lok P resin injection head, the bolter carousel completes bolt installation in a three-stage process of indexing into position after drilling, extending to complete polyester resin injection and nut tensioning of SDA and dynamic MPA self-drilling bolts.

7 Platform bolter conversion

Inherent operator risk when bolting with platform-type, scissor deck-style bolters is always present. The machine is a semi-mechanised bolter which requires extensive operator engagement. The main areas for improvement provided are as follows:

- Operator safety:
 - Reduction of operator proximity to high-risk zone.
 - Reduction of operator engagement, leading to a reduction in hand injuries.
 - Increase in operator ergonomics—screen manipulation and manual inserting of resin cartridges.
 - Cleaner work area, removing the requirement to store and stage resin cartridges.
- Automation, productivity and quality:
 - Reduction in operator engagement—hand-stabbing bolts and resin cartridges.
 - Mechanised bolting system with indexing installation improves productivity.
 - Incomplete bolt encapsulation using resin capsules. J-Lok P resin injection ensures full encapsulation.

7.1 High-risk zone

Operator safety and risk management is critical to any mining operator. The high-risk zone is forward of the last row of installed rockbolts. The high-risk area is where the operator is required to load bolts and mesh in multiple configurations alongside unsupported ground. This zone and the high potential for fall of ground is a significant hazard to any operator.

General platform bolter operating procedure requires operators to perform tasks in the high-risk zone, particularly when meshing and bolting. Figure 17 shows the operator forward of the last row of installed bolts. The average time an operator performs tasks in the high-risk zone is 35 seconds per bolt installation.

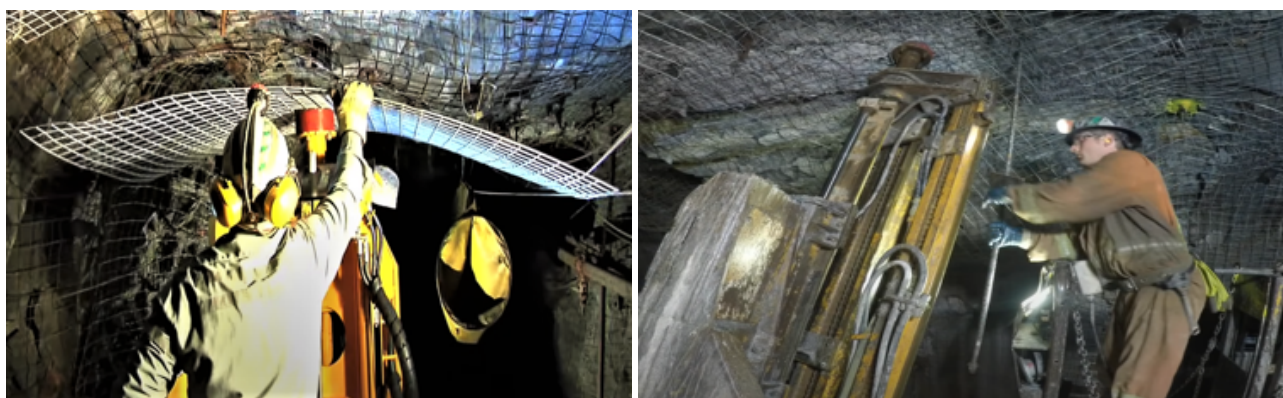


Figure 17 Operator in the high-risk zone operating a Maclean bolter, showing the installation of mine mesh and resin bolting

7.2 Eliminating operator exposure using resin injection

The platform bolter requires that the operator manually guide the bolt into the hole while the drifter and feed is in operation. The Komatsu TR10 bolting boom offers a flexible bolt centraliser which allows the bolt to be pre-loaded, supported and guided into the hole without the operator being in the high-risk zone. Mesh handling is controlled by introducing a screen handler as shown in Figure 18, which also removes the operator from the high-risk zone.

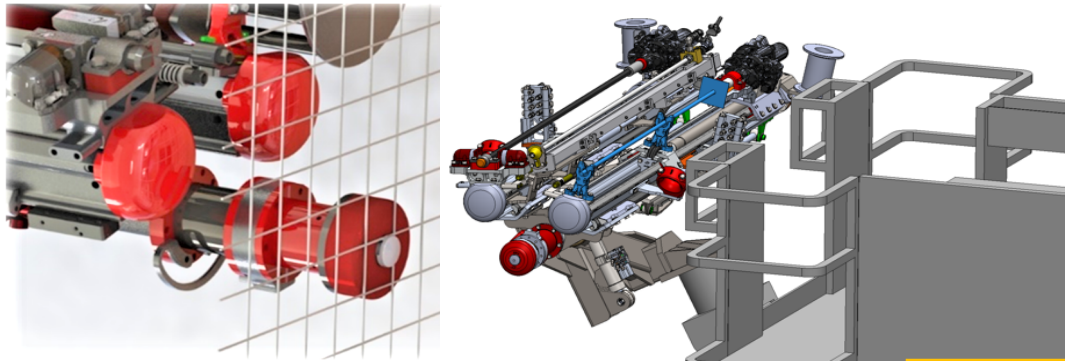


Figure 18 Komatsu TR10 bolter with screen handler, flexible bolt centraliser and J-Wand resin injection system

The retrofit's repetitive process improves safety with each bolt installed outside of the high-risk zone. The bolting head is positioned back into a safe loading configuration as shown in Figure 13, providing the operator with a simple and consistent bolt/mesh handling and loading process onto patented flexible centralisers. Constant resin supply is provided utilising the J-Lok P and J-Wand resin injection system, eliminating the need for the operator to load the resin capsules for bolting.

8 Jumbo bolting utilising integrated polyester resin injection

To maximise the advantages of drilling and resin injection, the J-Lok P system is modified to allow a successful application using twin-boom jumbo bolters. Utilising split-feed booms and J-Lok P polyester resin injection, Jennmar has developed rockbolts to suit jumbo installed self-drilling applications. The two bolting systems are detailed in Section 8.1 and Section 8.2.

8.1 Jumbo pre-drilling installation method

The pre-drillhole method uses percussion to drive hollow Jennmar SDA or the internationally patented dynamic MPA (US patent no. 10,941,657) bolt into drill holes as shown in Figure 19. After bolt installation, the same boom that installed the bolt aligns a resin injection nose-cone onto the bolt end. After a small boom movement, the resin injection cone assists in easy connection and sealing against the end of the installed hollow bolt. Once sealed against the end of the installed hollow bolt, the injection pump loads the rockbolt and borehole with polyester resin. The advantage of using this method is that there is no sacrificial drill bit needed to install bolts. This is a small cost-saving benefit, although the disadvantage is a slower installation process with only one boom bolting and the opposite boom drilling. Self-drilling is applicable in this method, although disengaging from self-drilling anchors can be difficult when bolt installation is complete, even when utilising gripper jaws to try and disengage from the SDA.



Figure 19 Polyethelene-coated dynamic Jennmar MPA bolt prepared for installation and resin injection. This provides a corrosion-protected, 50 kJ dynamic 300 kN, fully encapsulated first-pass installation

8.2 Falcon Bolt and simultaneous twin-boom installation method

Utilising the innovation patent AU2021105904 Jennmar Falcon Bolt (Figure 20) and Patent Cooperation Treaty application 2022901533 Jennmar Falcon Bolt dolly, simultaneous Falcon Bolt installation is achieved.



Figure 20 Anatomy of the Jennmar Falcon Bolt configuration

Installation of the Falcon Bolt requires no modification to the jumbo boom and is shown mounted to the jumbo split-feed boom in Figure 21. The Falcon dolly connects directly to a standard T38 or T45 drifter shank. The novel dolly design is mounted the same way as standard resin bolting processes. The Falcon dolly is a one-pass system that drills and tensions a bolt in a single installation process. This design allows each jumbo boom to drill and tension a bolt simultaneously, speeding up development processes significantly. When operations are staggered, the operator can drill utilising one boom while tensioning and resin injecting the second bolt utilising the opposite boom. This step is repeated until the drive is fully rock bolted.



Figure 21 Jennmar Falcon Bolt prepared for installation utilising the Falcon dolly and the patented J-Lok P jumbo resin injection assembly ready to inject installed hollow rockbolts

In the majority of installations pull tested, bolts recorded test results of 20 t without being cement- or resin-grouted. This provides immediate pre-tensioned rock reinforcement. Utilising the J-Lok P jumbo resin injection system (patent number US 10,253,628 B2), installed Falcon Bolts can be immediately resin-injected. The jumbo resin injection and installation process using a Falcon dolly is shown in Figure 22.

A complete Falcon Bolt installation is generally completed in 2.45 to 3.45 seconds, including resin injection. The advantages of utilising a J-Lok P Falcon bolt system are:

- Bolts can be installed in any ground type and are not affected by collapsing drill holes.
- Falcon Bolts can be supplied with an engineered polyethylene coating for corrosion protection.
- Falcon Bolts can be supplied in a dynamic MPA version with absorbed energy capacity to 50 kJ.
- Bolts are pre-tensioned upon installation and can be pull tested to 20 t without grouting.
- J-Lok P polyester resin injection of installed bolts can be completed immediately.
- Two booms can be operated simultaneously to install two Falcon Bolts at the same time, improving development efficiency.

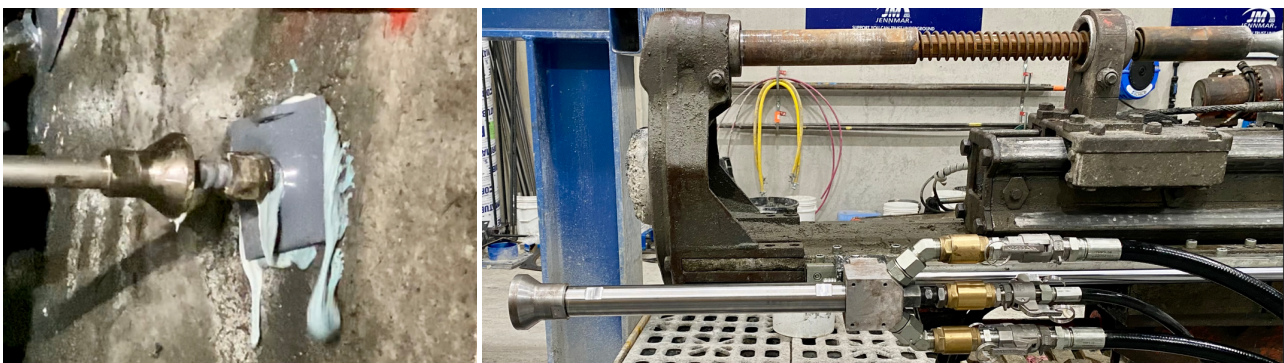


Figure 22 J-Lok P specialised jumbo resin formula injection, patented injection head and Falcon dolly shown mounted to a split-feed boom

9 Cable bolting utilising integrated polyester resin injection

Mechanised cable bolting machines are a successful method for installing cable bolts. Most seven-strand cable bolts are 15.2 mm (25 t) and 17.8 mm (35 t), and can be installed as single- or twin-strand options. Although the machines installing cable bolts are well designed, one issue in the installation process is the cement grout setting time. The set time can often be 12–24 hours before re-entry is possible.

Urea silicate resin has been used in cable bolter applications, but this required an engineered injection head to be installed on the end of the grout tube, which is susceptible to damage. It is also difficult to install, has issues with resin setting in the injection heads, can be difficult to manage in terms of resin set times and requires significant maintenance to remain operational.

The proven J-Lok P system uses a polyester resin with a 25–30 minute set time. This allows ample time to inject drilled cable bolt holes, install cable bolts and, if necessary, relocate the cable bolting machine to advancing drill holes for further cable installations.

The J-Lok P system utilises a standard OEM grout tube and reel as shown in Figure 23. The main change is adapting a rotary union for injecting the catalyst, mastic and water flushing lines for cable bolting.



Figure 23 J-Lok P resin injection utilising a standard Sandvik grouting process

Due to the volume of resin used and available space on cable bolting machines, large on-board resin and catalyst tanks are easily mounted on the cable bolting grouting deck. High-pressure and feed resin injection modules are used to allow long drill holes to be filled quickly. Figure 24 shows a typical installation in the sidewall with cable installed into polyester resin.

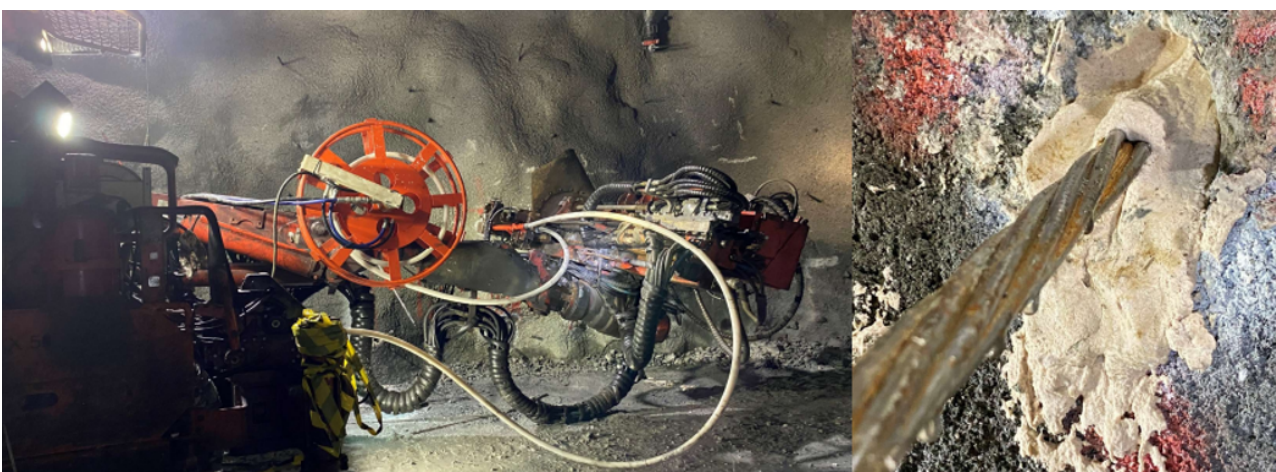


Figure 24 J-Lok P resin injection and cured J-Lok P resin bonding of a 15.2 mm cable bolt into a drillhole

Polyester resin is more expensive than cement grout. Therefore resin injection is a project-based application where fast curing times and quick re-entry times are needed. Many mines have a 12–24 hour cement grout cure time before mining can resume. Mines with single-entry development or critical infrastructure would benefit mostly from this system.

10 Conclusion

The J-Lok P system has been in service for seven years. Continuous improvement, miniaturisation, adapting polyester resin injection across various markets and applications, and safety improvements have been beneficial to the mining industry, particularly mines in poor ground.

The J-Lok P system now provides significant safety, quality control, efficiency and automation improvement for the mining, construction and tunnelling industries.

References

ASTM International 2002, *Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials (ASTM D790-02)*, ASTM International, West Conshohocken.

- Faulkner, D, Stankus, J, Ma, K & Ma, L 2017, 'Multiple point anchor (MPA), self-drilling, hollow core yielding bolt with injectable J-Lok P resin system for high-stress and squeezing ground conditions', *Proceedings of the 51st US Rock Mechanics/Geomechanics Symposium*, American Rock Mechanics Association, San Francisco, pp. 533–536.
- Roberts, T & Faulkner, D 2019, 'Polyester resin injection of dynamic resin and cable bolting systems to improve development efficiency', in J Hadjigeorgiou & M Hudyma (eds), *Ground Support 2019: Proceedings of the Ninth International Symposium on Ground Support in Mining and Underground Construction*, Australian Centre for Geomechanics, Perth, pp. 505–518, https://doi.org/10.36487/ACG_rep/1925_36_Roberts
- Stankus, J & Ma, K 2018, *Comparison of Pumpable Resin, J-Lok P vs Urea-Silicate White Paper*, Keystone Mining Services, Pittsburgh.
- Watt, G, Roberts, T & Faulkner, D 2018, Single pass drill, install and inject self-drilling resin bolt application in poor ground, *Proceedings of the Fourth Australasian Ground Control in Mining Conference*, Australasian Institute of Mining and Metallurgy, Carlton, pp. 323–343.