



Est. 1994

Inventing Solutions

Professional Engineers and Geoscientists

Consulting Field Services Manufacturing
Civil Mining Petroleum



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Introduction

Over the past 25 years, Sigra has found solutions to problems associated with the ground in the fields of mining, civil and petroleum engineering. To do this it has had to innovate both in the ultimate solutions provided but also in the testing techniques it uses, the analysis applied and theory behind the analysis.

During this period Sigra has worked in the fields of:

- Underground coal mining geomechanics including outbursting and rockbursting
- Tunnelling
- Water drainage from mines and civil engineering works
- Coal seam gas drainage
- Slope stabilisation
- Total mine design
- Commercial gas production
- Control of gas wells

To do this, Sigra has built a substantial testing capability including:

- Rock stress measurement
- Rock property measurement
- Gas content measurement
- Gas desorption behaviour
- The determination of fluid flow and storage parameters in the ground
- Fluid pressure determination

Sigra has also developed exploration and production equipment including:

- Specialist drilling tools
- Well control systems
- Managed pressure drilling systems
- Well testing
- Gas/water/fines separators
- Field data acquisition and control systems

Sigra's clients are major mining and petroleum companies, public transport and power groups. Sigra also works with consulting groups. All have benefitted from Sigra's multi-disciplinary approach and ability to conceive and physically build solutions.

Why Choose Sigra?

INNOVATION

Sigra prides itself on being innovative - we invent things. Sigra has developed a wide range of new equipment and techniques to solve difficult problems which others have not been able to solve using conventional methods. We do our own research and development to achieve this - leading with new technologies, rather than following existing ones. We take a problem, develop a theoretical solution, design and build new equipment to practically implement it, carry out the field measurements, interpret and validate the data, and recommend a practical solution. This is not a conventional generic approach.

PEOPLE

Sigra deliberately employs people from diverse professions, backgrounds, disciplines, ethnicities and ages - we have:

- chemical, civil, electronic, geotechnical, mechanical, mining and petroleum engineers
- geoscientists, hydrogeologists, mathematicians, computer programmers
- skilled tradespeople to manufacture mechanical and electronic items for a range of data acquisition, control systems and specialised drilling equipment
- laboratory staff skilled in rock mechanics and gas testing
- commercial skills.

We have a flat, multi-skilled organisational structure:

- field
- laboratory
- analysis & reporting
- design & manufacturing
- mechanical and electronic workshops
- business development & administration.

EARTH INDUSTRIES

Sigra deal with all matters concerning the Earth. We are equally comfortable servicing:

- the mining industry,
- the petroleum industry,
- civil engineering earthworks, and
- groundwater.

GLOBAL

Sigra provides solutions and products to clients across the globe.

ETHICS

Sigra report facts, findings and realistic conclusions from the perspective of engineering, science and mathematics. We do not distort the facts.



Our People

Dr Ian Gray - Managing Director

PhD, MAppSc (Hydrology, Engineering Geology), BE (Civil), RPEQ
ian@sigra.com.au

Ian founded Sigra as a one-man business in 1994 - since then the company has grown under his guidance. Ian is a multidisciplinary engineer and inventor with a vast, 42-year professional career spanning the civil, mining and petroleum industries across multiple continents, both in government research roles and industry roles. He has published over 70 papers and regularly shares findings distilled from Sigra's research at professional institutions and industry conferences. Ian holds some 20 patents on such diverse topics as mining systems and gas-liquid separators.

Jeff Wood - Principal Geologist

BSc (Geology)
jeff@sigra.com.au

Jeff has close to 50 years of experience in geology across base metals and coal. Before joining Sigra, Jeff held senior positions at Anglo American and BHP mining operations throughout Australia. Jeff specialises in exploration, mining geology, gas evaluation, gas production and wastewater disposal. He joined Sigra In July 2008 as a Principal Geologist and currently heads Sigra's geological department, playing a major role in the development of Sigra's laboratories and geological services.

Tim Harvey - Principal Engineer

Dip (Civil), Associate Dip (Mining)
tim@sigra.com.au

Tim has 45 years of engineering experience, firstly as a Civil Engineer and then more substantially as a Mining Engineer. Tim has worked with Sigra since 2015 and has assisted with both practical and consulting engineering projects. Tim's recent experience has been mainly associated with mine ventilation, gas management and spontaneous combustion control. He also has extensive experience in mine planning and scheduling, feasibility studies, economic modelling, budgeting and project management, mine drainage, shaft sinking and mining through difficult conditions.

Tim Gibbons - Business Development Manager

BE (Mining), MBA
timg@sigra.com.au

Tim's 40 years of experience is evenly split between mining operations and corporate business development. In addition to a strong background at a senior level in all aspects of operations, Tim has been involved in both commercial and technical aspects of new mine development, from pre-feasibility studies to initial production. He has worked for owners and contractors and understands the issues of these two groups working together. In 2018 Tim brought his wealth of commercial experience to Sigra in the role of business development manager.

Brett Stewart - Projects Manager

BE (Mechanical)
brett@sigra.com.au

Brett joined Sigra in 2006 as a mechanical engineer providing field services and mechanical engineering design. Since then he has been integral in the continued improvement of Sigra's field systems and operations. Brett has been involved in most of Sigra's field operations since 2006 and specialises in co-ordinating and managing projects, liaising with stakeholders and providing solutions to complex issues in the field.

Darryl Smith - Senior Engineer

BE (Chemical)
darryl@sigra.com.au

Darryl joined Sigra in 2007, bringing over 10 years of experience as a chemical engineer with him. Darryl manages field projects while also playing a leading role in the development of Sigra's laboratories. His experience in chemical engineering and geomechanics provides him with a broad knowledge which he effectively applies to in-situ stress, permeability, gas content and desorption analysis and reporting.

Ben Seeto - Senior Engineer

PhD, ME (Mechanical), BE (Mechanical), RPEQ
ben@sigra.com.au

Ben is a registered professional engineer with 30 years of experience as a Mechanical Engineer. His expertise includes mechanical design, fluid mechanics and software development. He has experience working in the CSG, energy and environmental industries. Since joining Sigra in 2014 Ben has designed a hydraulic wellbore cementing model and worked on the development of a three-dimensional non-linear, anisotropic analytical model of rock behavior.

Russell Noonan - R&D and Special Operations

Dip (Industrial Arts)
russ@sigra.com.au

After 31 years of teaching agricultural engineering as an advanced skills teacher, Russ moved to Sigra in 2006. Since then he has led the fabrication of most of Sigra's proprietary equipment. Russ has the ability to turn ideas for complicated problems into elegant solutions that are both functional and economical. Russ has an enviable understanding of mechanical and hydraulic systems, electronics, rubbers, metals and composites.

Our People

Tatyana Kolesnichenko - Financial Controller

MPAcc, BBus (Economics & Finance)

tatyana@sigra.com.au

Tatyana joined Sigra in 2014 as an accountant. She has since gone on to become the financial controller. Tatyana works closely with the Sigra leadership team to assist them in meeting strategic business objectives. She implements working procedures to increase efficiency and devises company financial strategy and overall cost structures to reduce overheads and position Sigra for growth.

Xiaoli Zhao - Reservoir Engineer

ME (Petroleum), BSc (Geology)

xiaoli@sigra.com.au

Xiaoli is a gifted reservoir engineer with 7 years professional experience. She specialises in reservoir characterisation, software development, well testing analysis and geomechanics. Xiaoli joined Sigra in 2015 and has since gone on to develop numerous in-house software programs for analysing complex rock mechanics and gas sorption modelling. She also completes technical reports and has co-authored several published papers.

Ratheesh Keloth - Mechanical Engineer

BE (Mechanical)

ratheesh@sigra.com.au

Ratheesh joined Sigra in 2007 as a field engineer. While working at Sigra he completed his BE in mechanical engineering. Ratheesh is a highly practical engineer who can design and fabricate testing equipment. He also provides leadership in the field with an ability to troubleshoot and provide workable solutions when problems arise. Ratheesh has an excellent understanding of mechanics, fluid systems, instrumentation, drafting and machining.

Andrew MacTaggart - Civil Engineer

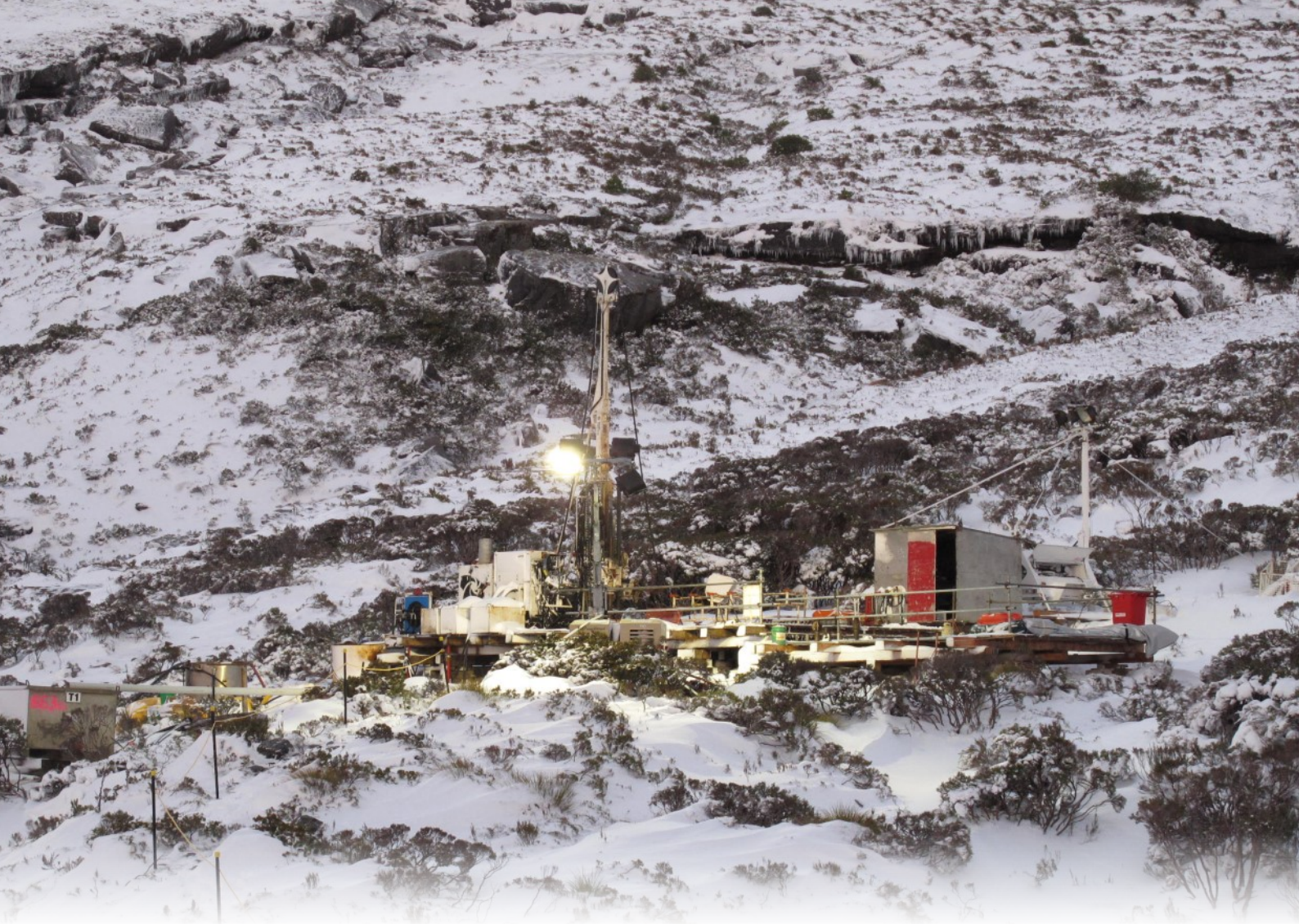
BSc (Civil)

andrew.mactaggart@sigra.com.au

Andrew has 10 years of professional experience as an Engineer in the civil, mining and coal seam gas industries. His expertise include geomechanics, fluid mechanics, directional drilling, survey systems and cement technology. Andrew joined Sigra in 2016 and has since gone on to manage all groundwater monitoring installations from proposal to the final report. He has also conducted research in to cement technology and rotary steerable drilling systems.

Sigra's ability to provide innovative solutions requires a range of professional engineers and geoscientists backed up by technicians, trades people and administrative staff - some of whom are the most inventive people in the organisation.





Field Services

ROCK STRESS MEASUREMENT

Sigra provides rock stress measurement by overcoring, hydrofracture, hydrojacking, borehole breakout analysis and rock core ovality analysis. By actively engaging in research and development, Sigra is able to stay at the forefront of stress measurement technology. Sigra can recommend what techniques to use based on ground conditions, experience and budget.

Overcoring is conducted using Sigra's IST system. The biaxial measurement system is highly regarded for its quick testing times, high success rate and accuracy. Over 1,300 tests have been conducted in the mining, petroleum and civil industries throughout the world.

The rock-core elastic properties and the fluid component of effective stress are measured in-house using state-of-the-art uniaxial and triaxial loading techniques.

Hydrofracture and hydrojacking stress measurement methods are conducted using the Sigra designed hydrofrac tool, packers and high pressure water pump. These direct measurements of in-situ stress require careful planning and analysis to provide realistic results.

Borehole breakout and core ovality are stress analysis techniques that do not require Sigra equipment to be deployed to site and can be determined by reviewing geophysical logs and core samples.

Field Services

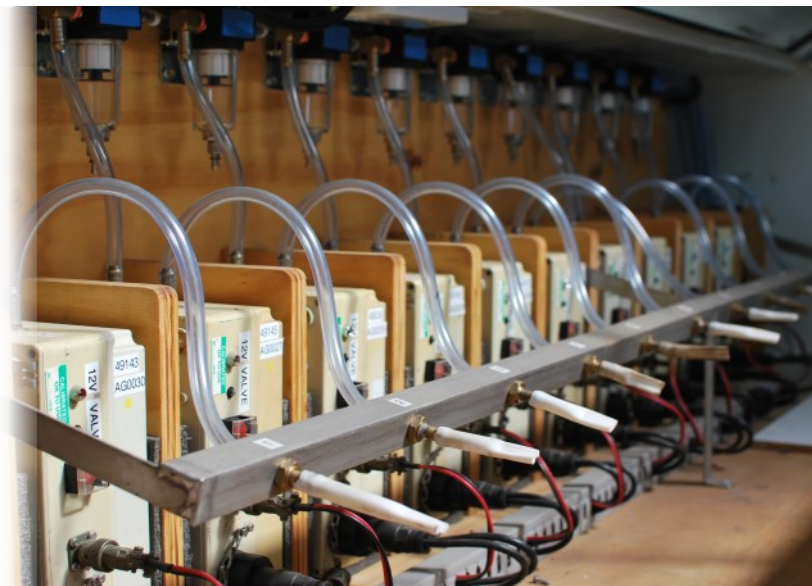
PERMEABILITY AND STORAGE MEASUREMENT

Sigra provides accurate average permeability measurements by drill stem testing (DST), falling head-injection testing and interference testing. These tests provide a true assessment of formation permeability, a measurement of well bore damage, the ground fluid pressure and an indication of the mean effective radius of the investigation. Inhomogeneity, anisotropy and storage parameters can also be determined using pulsed directional DST. Sigra can also conduct permeability testing from underground. Sigra has developed these permeability measurement equipment and techniques to be simple to conduct like a civil engineering industry packer test, which yield all the advantages of tests conducted by the petroleum industry.



GAS CONTENT

The direct measurement of gas content in coals is one of the most basic and important measurements in determining a coal seam gas resource. Sigra has developed and refined four methods of gas content measurement—core desorption, chip desorption, gas content without coring and a gas capture core barrel .



LONG TERM MONITORING AND DATA COLLECTION

Sigra designs, manufactures and installs long term monitoring systems for the civil, mining and petroleum industries. Sigra excels in deep and shallow well monitoring systems using proprietary technologies. With a range of pressure transducers, cable types and borehole sealing methods, Sigra can design appropriate monitoring solutions for most environments.



Laboratory Services

Sigra has developed its laboratory capability to measure rock and coal mechanical properties and gas adsorption behaviour into coals or shales. It also has the capability to measure drilling fluid or cement grout rheology.

GEOMECHANICS LABORATORY

Sigra has developed world leading methods to determine the mechanical properties of rock taking into account anisotropy, non-linearity and poroelastic behaviour. This work is conducted in triaxial cells developed in house. Sigra has also developed the hydrostatic testing process to determine the properties of rock fragments. This method is particularly useful where whole core cannot be retrieved. Shrinkage testing is also undertaken to determine how gas loss affects coal and shale dimensions and subsequent gas release mechanisms and profiles.

These measurements are important in modelling the stress changes brought about by excavation or fluid withdrawal. Sigra also measures rock toughness, tensile strength and uniaxial strength.



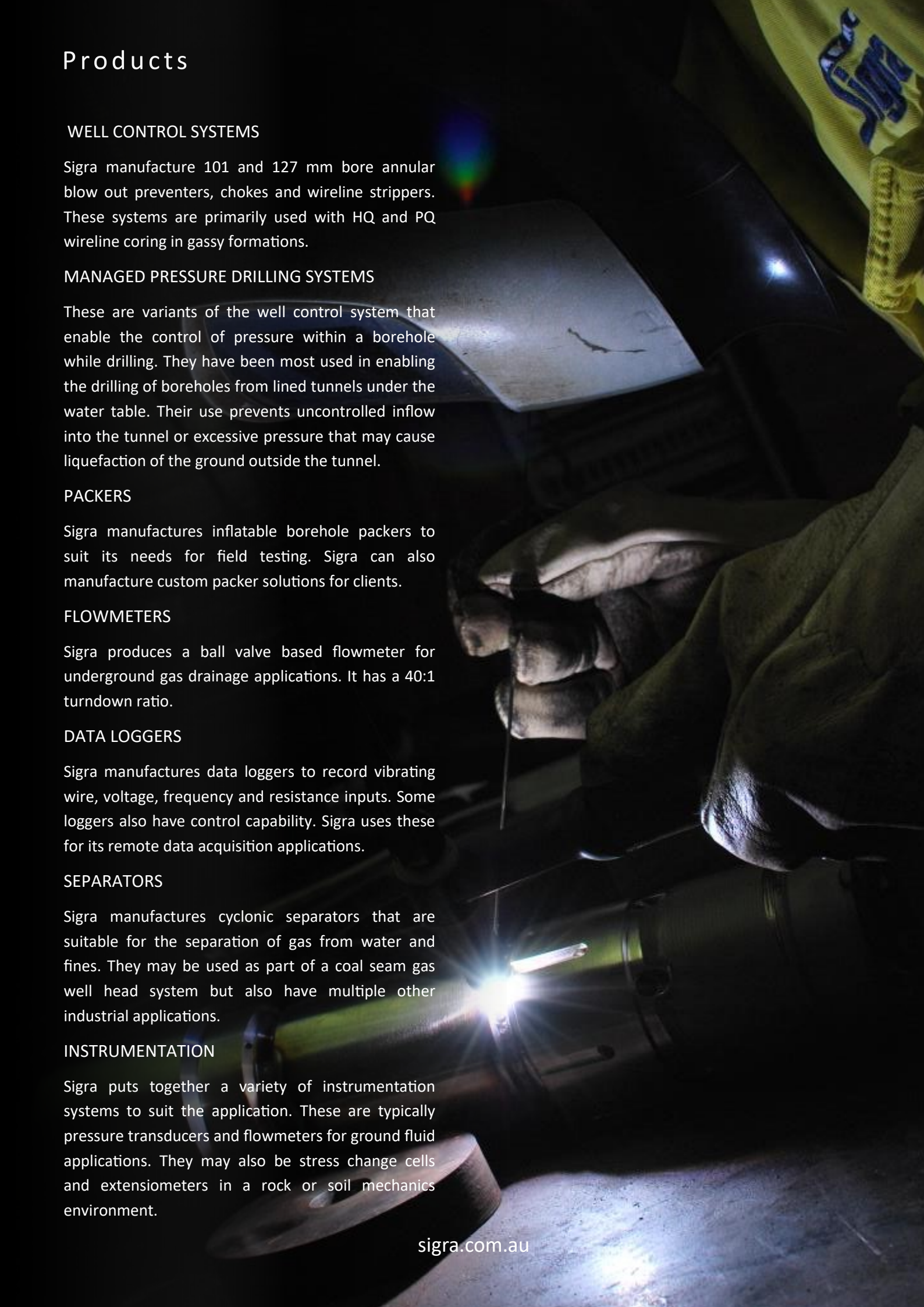
COAL LABORATORY

The coal laboratory is substantially devoted to the measurement of gas in coals and shales. This includes gas content measurement and the measurement sorption isotherms of gas content versus pressure. The latter may be measured by normal laboratory techniques or as native isotherms. Native sorption isotherms describe the gas content versus gas pressure relationship on first degassing. They are particularly important in mixed gas environments where the accepted methods of combining individual gas isotherms are inaccurate. The laboratory also undertakes more normal testing such as proximate analysis, moisture content, density and testing for mineral types within the coal.

FLUIDS LABORATORY

Sigra has the ability to test drilling muds and cement grouts for their rheological behaviour in its large size rheometer. This provides the input information for modelling of borehole flow regimes or cement grouting processes. Sigra can also calibrate gas flowmeters in its laboratory.

Products



WELL CONTROL SYSTEMS

Sigra manufacture 101 and 127 mm bore annular blow out preventers, chokes and wireline strippers. These systems are primarily used with HQ and PQ wireline coring in gassy formations.

MANAGED PRESSURE DRILLING SYSTEMS

These are variants of the well control system that enable the control of pressure within a borehole while drilling. They have been most used in enabling the drilling of boreholes from lined tunnels under the water table. Their use prevents uncontrolled inflow into the tunnel or excessive pressure that may cause liquefaction of the ground outside the tunnel.

PACKERS

Sigra manufactures inflatable borehole packers to suit its needs for field testing. Sigra can also manufacture custom packer solutions for clients.

FLOWMETERS

Sigra produces a ball valve based flowmeter for underground gas drainage applications. It has a 40:1 turndown ratio.

DATA LOGGERS

Sigra manufactures data loggers to record vibrating wire, voltage, frequency and resistance inputs. Some loggers also have control capability. Sigra uses these for its remote data acquisition applications.

SEPARATORS

Sigra manufactures cyclonic separators that are suitable for the separation of gas from water and fines. They may be used as part of a coal seam gas well head system but also have multiple other industrial applications.

INSTRUMENTATION

Sigra puts together a variety of instrumentation systems to suit the application. These are typically pressure transducers and flowmeters for ground fluid applications. They may also be stress change cells and extensimeters in a rock or soil mechanics environment.

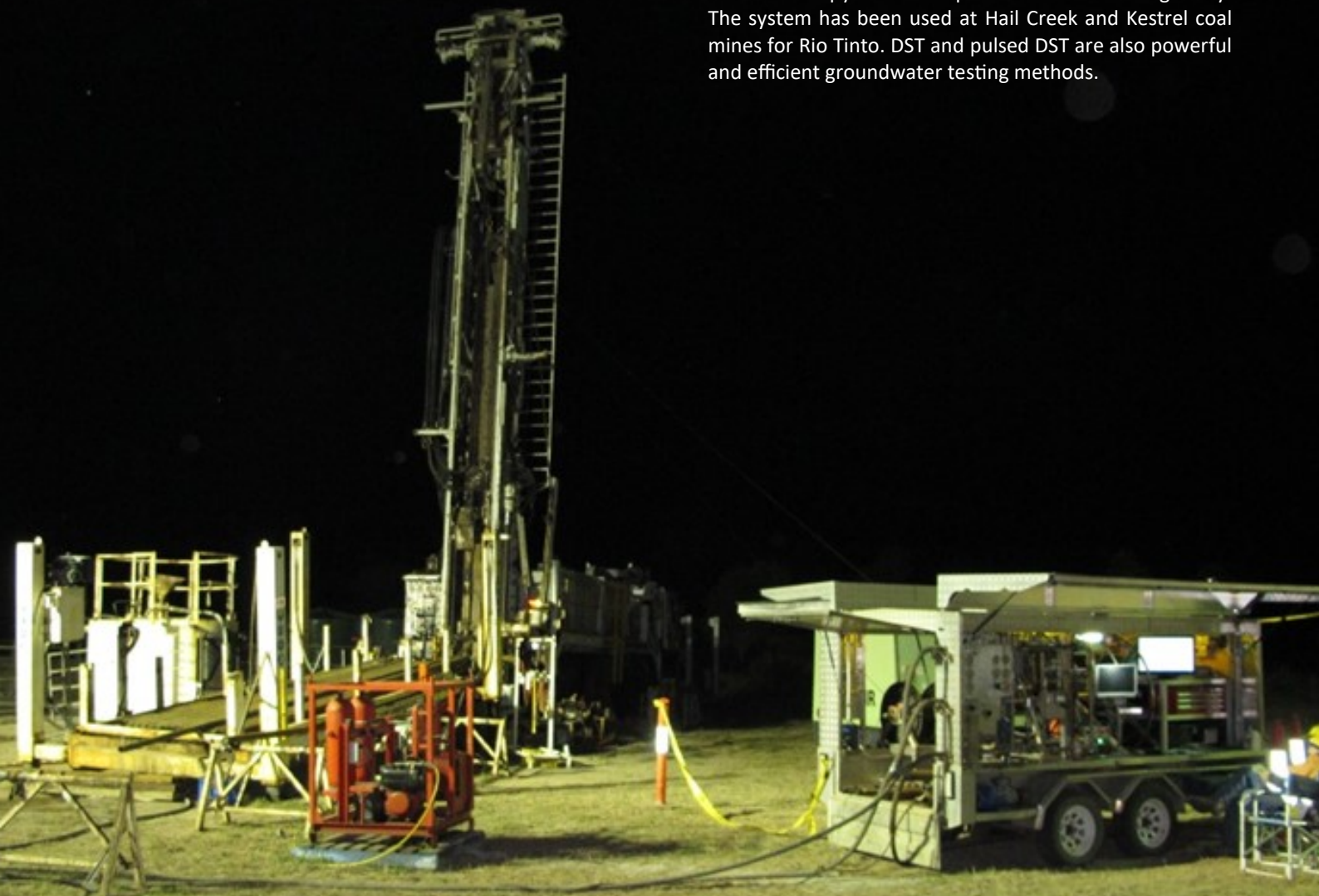
Significant Projects

ISAAC RIVER INFLOW TO MORANBAH NORTH COAL MINE

In 2004 Moranbah North coal mine (Anglo American) was concerned that flooding of the Isaac River would enter subsidence fractures above the goaf and flood the mine. Sigra undertook a comprehensive ground testing programme through slanted boreholes to develop information on directional permeability. It showed that the strata closed up as the goaf reconsolidated and flooding would not occur.

PERMEABILITY MEASUREMENT

In 1999 Sigra undertook modified packer testing and then a conventional interference (by injection) test to determine reservoir parameters at Grasstree coal mine (Capcoal, Anglo American). Results of the packer testing showed a great number of inadequacies existed in this conventional approach. To overcome the inadequacies of the traditional packer testing, Sigra developed its own wireline drill stem test (DST) system in 2001. This provided far greater detail of formation permeability, radius of investigation and borehole damage. Sigra's DST system was used in mining and for the burgeoning coal seam gas industry. Sigra's 2nd generation wireline DST system was developed in 2005. The new DST system enables test zones to be straddled, and testing is possible to depths of 1300 m. It is still currently in use by Sigra. The problem of measuring directional permeability and storage behaviour was overcome in 2013 by using pulsed DST testing. This involves placing a sealed pressure transducer in the first hole and then testing a second hole and measuring the piezometric change in the first hole. This process can be repeated in third and fourth holes so that anisotropy can be separated from inhomogeneity. The system has been used at Hail Creek and Kestrel coal mines for Rio Tinto. DST and pulsed DST are also powerful and efficient groundwater testing methods.



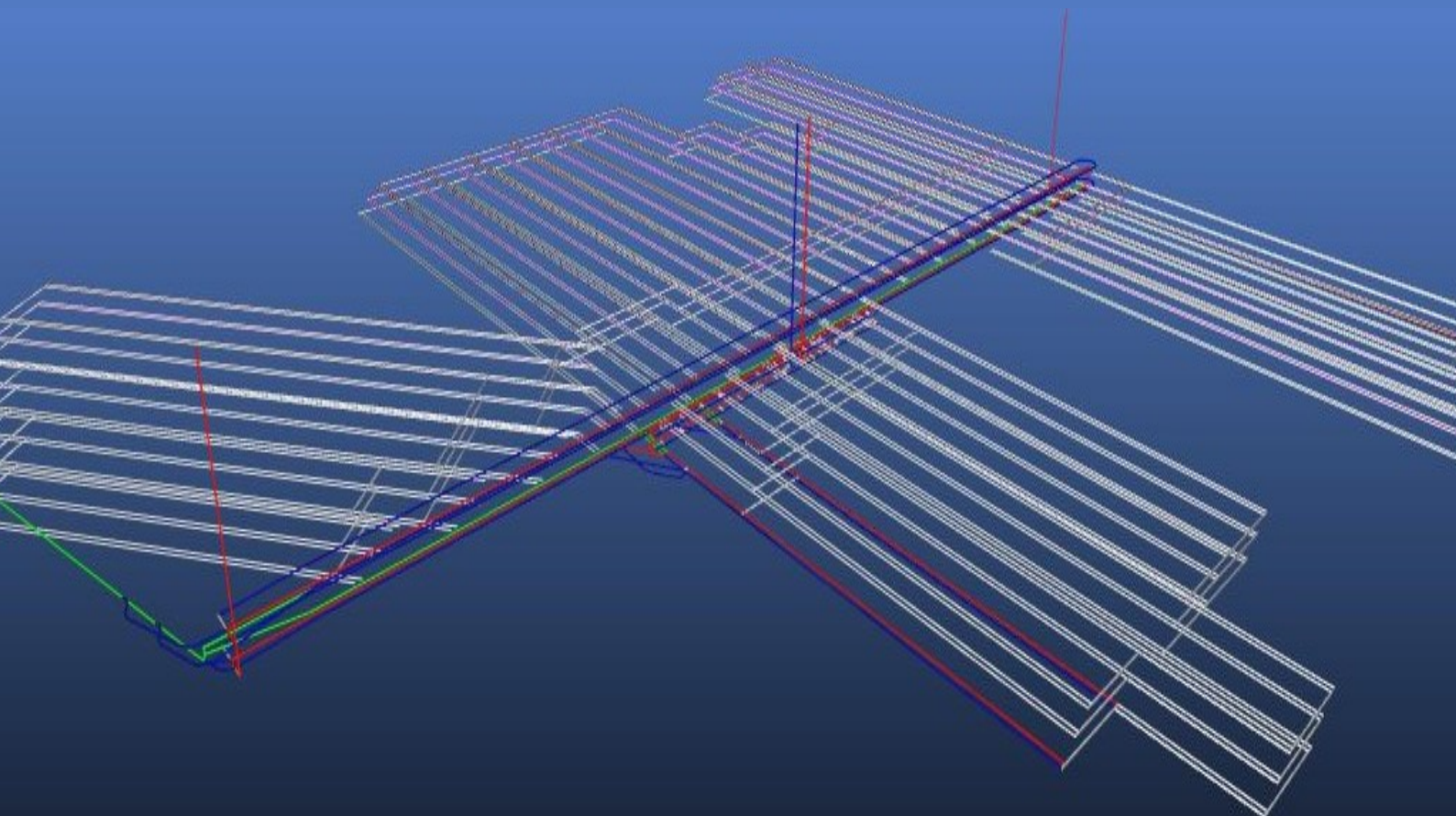
Significant Projects

BELVEDERE MINE EXPLORATION AND DESIGN

In 2010 Vale approached Sibra to make sense of exploration data at a potential deep mine site in Queensland. Much of this work had been inadequate, and a new drilling campaign was arranged, with Sibra providing all the testing and much of the geology. This work involved stress measurement using Sibra's IST tool, gas content measurement of core, geotechnical logging, permeability measurement using Sibra's DST tools, the measurement of coal shrinkage with degassing, and sorption isotherms. Sibra organised an international conference to consider the mine design. It then produced a multi-seam longwall mine design for the lease involving mine layout, sequence, drainage and ventilation. The drainage used the latest tight gas petroleum technology for degassing, adapted into an underground environment, combined with stress relaxation brought about by mining an adjacent seam. Sibra has completed a similar exploration and design exercise at Kestrel mine for Rio Tinto.

GAS CONTENT MEASUREMENT

Sibra has developed the gas content measurement of coals and other rock during the decades of its operation. It provides conventional core desorption with analysis of lost gas, which takes account of when desorption really occurs in the borehole. An improvement on this is a gas capture core barrel where any lost gas is stored for measurement on surface, thus avoiding lost gas. Sibra also measures gas content from cuttings. To avoid problems with lost gas in this situation, Sibra has developed and tested at Grasstree mine (Anglo American) a system where drilling is conducted in an overbalanced state so that reservoir fluids do not enter the wellbore, and any gas liberated on cutting or from particle transit to surface is captured at the well head and measured. This system is suitable for gas content measurement in lower permeability conventional or unconventional reservoirs, and is ideal for use on thick gas bearing strata.



Significant Projects

PIEZOMETERS/RESERVOIR MONITORING

Sigra began installing piezometers in coal seams in the early 2000s. Initially piezometers were installed by the traditional process of placing a pressure transducer in a sandpack covered with bentonite and grout. This was a slow and expensive process, and not suitable for multilevel or deep installations. Then the process of cement grouting transducers directly into boreholes was used. With technique there was water loss by filtration into the formation making the cement very impermeable, thus slowing the transducers response to pore pressure changes. Transducers installed by this technique could not be tested. The use of bentonite cement mixes to leave some permeability in the cement grout caused intra-hole connection and generally showed near hydrostatic pressures. To overcome these problems, Sigra developed an installation process using a highly impermeable cement grout that is displaced by injecting water from around the transducer tip and creating connection to the ground to be tested. The system is testable for both intra-connection between monitoring zones and connection to the zone to be monitored. Up to 7 transducers in a single well have been successfully installed to 600 m depth using this system. It can be used for much deeper holes or is also eminently suitable for shallower civil work.

LANDSLIDE AT CUT 3 AND CUT 4, PACKAGE B – SOUTH WEST CORRIDOR (CENTENARY HIGHWAY EXTENSION) REDBANK PLAINS

In 2008 Sigra was approached by the Department of Transport and Main Roads, Queensland, to provide assistance in solving the problem of two large, moving cut slopes. The slopes had been studied extensively but continued to move at 1 mm per day in dry conditions and 3 mm per day in wet conditions. This movement was destroying the pavement of a newly constructed road. Sigra provided groundwater field testing by well tests, with multiple piezometric monitoring points, followed by analysis. Sigra implemented a drainage strategy with fully automated control and monitoring using in-house data acquisition and control systems. Part of the analysis was a model that could, by analysing piezometric trends, enable the areas of water ingress and loss from the slope to be determined. This could be done in real time using Sigra's data acquisition system.



Significant Projects

TAHMOOR COAL MINE STRESS DISTRIBUTION

During 2011 and 2012 Glencore utilised Sibra to conduct nearly 100 IST stress measurements. Glencore then asked Sibra to analyse the complex stress distribution over the lease. This was done using the IST measurements, borehole breakout, and examination of the faulting in the area as determined from seismic survey. The result was a complex distribution with clear stick slip behaviour on the faults, which led to sudden 90 degree shifts in major stress orientation and changes in stress magnitude. This behaviour has been recognised in other active tectonic environments. The use of the tectonic strain concept, developed by Ian Gray in 1999, facilitated this analysis. Tectonic strain is the strain to which rock has been subject to generate the stress within it. The use of tectonic strain removes complications associated with the varying stresses in different stiffness rocks.

STRESS PATH WITH DRAINAGE/PRODUCTION

The stress path describes the effective stresses within the ground, with special reference to the stress changes due to drainage or production of fluids. It is particularly important in coals as their permeability is highly stress dependent. The permeability may improve OR may reduce depending on the changing stress. This work was used in Ian Gray's 1983 PhD to describe 500 fold changes in permeability at Leichhardt Colliery (BHP). Since then it has been greatly developed. Currently stresses and fluid pressures are measured using hydrofracture in seam. The coal properties are measured in Sibra's triaxial or hydrostatic testing systems, and coal shrinkage on desorption is also measured, as is the sorption isotherm. This information is used in a model to predict how effective stress will change. In some cases the permeability will increase while in others it may reduce. Knowing this is vital to predict gas production. The changing stresses are not only important in the production of fluids but may also affect how coal pillars fail.



Significant Projects

WELL CONTROL SYSTEMS

In 1994 Sibra was given a contract to design and build a borehole pressurisation system for underground coal mine drilling. One of its notable features was the choke (pressure regulator), which was an elastomeric device which could pass through large particles transported in the drilling mud.

In 2001 Sibra was approached to build a blowout preventer (BOP) system for Lihir gold mine in Papua New Guinea. The purpose of this was to enable high wall drainage drilling in geothermal conditions. The boreholes were drilled using SIMCAS with a hammer and casing. The BOP permitted the safe withdrawal of all drilling equipment from the hole.

In 2004 Sibra started to supply the first of some 70 well control systems used in exploration core drilling in gassy conditions. These have been used in coal mining and coal seam gas exploration. In 2013, a variant of Sibra's well control system was used for site investigation drilling for the 30 km Temburong Bridge in Brunei.

In 2015 Sibra supplied underground well control units to BHP-Billiton Illawarra Coal operations. In 2016 Sibra was commissioned to build a pressure control system to enable managed pressure drilling from below the groundwater table from inside the Lian Tang tunnel in Hong Kong for VSL Intrafor/ Dragages.

ROCK PROPERTIES

In 2009 Sibra built its own laboratory to test rock properties. Initially this involved uniaxial testing for Young's modulus and Poisson's ratio. In 2011, Sibra was undertaking an exploration project for Vale in Queensland where most of the coal core retrieved was very broken. This breakage was a combination of stress, gas pressure and pre-existing structure within the coal. The problem was that it was essential to have some idea of the stiffness of the coal so that stress changes associated with mining and mine drainage could be determined. As a result, the process of hydrostatic testing of small strain gauged samples set in silicone resin was developed. Hydrostatic testing showed that the coal was highly nonlinear. With the surge in tunnelling around Sydney in 2015 it became apparent that the majority of the rock there was highly nonlinearly elastic. To cope with this Sibra built its own triaxial cell to test rocks. The test procedure adopted enabled the anisotropic, nonlinear and fluid pressure dependent (poroelastic) rock properties to be determined. This has shown that most rocks have vastly different properties to those generally gained from uniaxial tests and which are used in modelling excavations. Sibra is at the forefront of rock properties determination.



Projects, Research and Development 1994—2006

Projects

1994

- * Outburst risk assessment
- * Expert Witness—Kidston gold mine, QLD accident
- * Research advice to University of Queensland in coal seam gas development. Queensland Electricity Commission (QEC) funded project

1995

- * Continuation of QEC coal seam gas study with the University of Queensland

1996

- * Hydrogen sulphide project at Southern Colliery, QLD

1997

- * Coal mine In-situ stress testing by Sibra IST
- * landslide rescue operation, Thredbo, NSW

1998

- * Coal mine In-situ stress testing by Sibra IST

1999

- * Reservoir assessment including interference test to determine directional permeability, Grasstree coal mine, QLD

2001

- * Supply of a geothermal well control system for SIMCAS at Lihir gold mine, PNG
- * Sibra IST system used for the first time in the USA

2002

- * Significant testing (DST and flow testing) for the coal seam gas industry
- * Installation of stress change cells from surface in coal pillars at Oaky Creek coal mine, QLD

2003

- * Geotechnical appraisal, Mt Norma copper mine, QLD
- * Study into potential for surface water inflow to goaf at Moranbah North coal mine, QLD

2004

- * DST well testing services for Arrow Energy, QGC and CH4
- * DST and Sibra IST across several coal mines
- * Piezometer installation and long term monitoring of coal seam strain change during drainage

2005

- * Sibra IST used for tunnelling geotechnical investigation in Sydney, NSW
- * Continued Sibra IST and DST across Australian coal mines

2006

- * International consultation to clients in Russia, China and Argentina dealing with gassy mines and coal seam gas development
- * Gunnedah Basin study for coal seam gas
- * Continued Sibra IST and DST in mining and coal seam gas industries
- * Mine geotechnical study, design and reserve estimation

Research and Development

1994

- * Development of a borehole pressurisation system for ACARP
- * Development of a triaxial core testing system for the University of Queensland

1995

- * Development of torque and thrust sensor for geosteering
- * Design of a high wall mining roof support system

1996

- * Development of a mixing valve for water/chemical infusion system to strip hydrogen sulphide from coal
- * First development of the Sibra IST overcore system

1997

- * Development of a gas drainage flowmeter

1998

- * Development of a borehole shut-off valve for gas drainage
- * Testing of drill rods for long hole drilling

1999

- * First Sibra data loggers designed, manufactured and installed
- * Development of the concept of tectonic strain to explain stress variations through sedimentary strata

2000

- * Development of a directional downhole hammer
- * Through-the-bit Drill-Stem Test (DST) system
- * Research into tectonic strain theory

2001

- * Development of geothermal blow out preventers
- * Development towards a geosteering tool for use in coal mining in partnership with CSIRO

2002

- * Continued development of the geosteering tool
- * Development of permanently cemented stress change cell

2004

- * Development of strain change cells to measure the deformation in coal seams during gas drainage

2005

- * Development of a through-the-bit straddle DST tool. This system allowed for testing to depths of 1300 m through HQ drill pipe or connected directly to the end of a drill string. This system was integral in determining gas reserves for the growing coal seam gas industry in Australia.

2006

- * Manufactured a 10" borehole packer system in 8 days
- * ACARP project into the study of outburst mechanisms
- * Development of the first automatic core gas desorption monitor

Projects, Research and Development 2007 – 2013

Projects

2007

- * In-situ stress testing by Sigra IST at Kurnell desalination plant in Sydney, NSW
- * Coal mining and coal seam gas reservoir testing throughout Australia
- * Coal seam gas work in Indonesia for Westside-KPC
- * Manufacture and sale of Sigra's well control systems

2008

- * Cut-3 slope hydrogeology and stabilisation, including major field works and analysis for the Queensland Government
- * Feasibility study into coal seam gas in Argentina
- * Underground outburst and gas drainage field study in Lenina coal mine, Kazakhstan
- * Increased use of the Sigra IST system for civil engineering projects
- * Increased use of Sigra's hydrofracture system for civil engineering projects

2009

- * Continued Cut-3 field work and analysis for the Queensland Government
- * In-situ stress testing by Sigra IST and hydrofracture for Brisbane Airport Link, QLD
- * Outburst and gas drainage consulting work Asian America Coal Inc in China
- * Coal mine exploration and design programme

2010

- * Continued field testing for the coal seam gas industry
- * Coal mine groundwater monitoring installations
- * Major stress measurement program at Tahmoor coal mine, NSW
- * Major mine investigation at Belvedere coal mine, QLD
- * Continued Sigra IST and DST testing for the coal mining industry

2011

- * Continued field testing for the coal seam gas industry
- * Belvedere mine exploration and design project involving geology, IST, DST, isotherms, stress path analysis
- * Consulting visit to Vorkuta coal mines in the Arctic circle, Russia.
- * Install deep well piezometers for Arrow Energy, QLD

2012

- * Investigation of Mount Davy coal mine for Solid Energy, New Zealand
- * Sigra IST and DST at Oaky Creek coal mine, QLD
- * Review of stress regime around Tahmoor coal mine, NSW

2013

- * Design a geotechnical plan for Holba gold mine, Russia
- * Major reservoir and geomechanics study of Grasstree coal mine, NSW
- * Major field work at Oaky North coal mine and Moranbah North coal mine, QLD
- * Gas reserve estimates for Vale and Caledon Resources
- * Review of mine plan for gas drainage at Wambo coal mine, NSW

Research and Development

2007

- * Development of coal isotherm measurement method utilising pure gases (normally methane and sometimes carbon dioxide or other gases if present)
- * Development of Sigra's economical well-control-systems specifically for HQ size wireline coring and open hole drilling

2008

- * Development of coal shrinkage measurement to provide information on how coal changes dimensionally with adsorption/desorption of gas
- * Development of permanently cemented pressure transducer installation methods to overcome delayed response characteristics
- * Developed concept for obtaining gas content from all strata while drilling open hole
- * Develop large network of Sigra data loggers

2009

- * Further development of stress path in coal which expanded on Dr Ian Gray's 1983 PhD. The incorporation of data collected from Sigra's stress and permeability field work, laboratory isotherms and shrinkage behaviour measurements provided further enhancements and proof of the importance of stress path determination to predict coal seam reservoir behaviour

2010

- * Most of Sigra's resources involved with the high volume of field testing for the coal mining and coal seam gas industries
- * Presented stress-path in coal seam gas reservoirs, and gas content from open hole drilling to the Asia Pacific Oil and Gas Conference

2011

- * Design of a multi-level gassy mine using hydrofracture from underground for initial seam entry, followed by seam extraction to relax strata and degas coal seams
- * Development of hydrostatic testing to measure the elastic properties of coal fragments. Hydrostatic testing revealed the extreme nonlinearity of the stress-strain characteristics of the coal samples

2012

- * Design and development of Sigra's cyclonic separator for the separation of gas, water and solids in petroleum and mining applications

2013

- * First field test of Sigra's gas content without coring system at Grasstree coal mine, QLD, to determine if strata other than coal seams were also sources of gas.
- * Advised the Mine Managers Association that a major revision of outburst criteria was required to ensure safe operation in underground coal mines

Projects, Research and Development 2014—Present

Projects

2014

- * Simulation of gas field behaviour to obtain reservoir properties at Grosvenor coal mine, QLD
- * Reservoir testing and piezometer installations at Hail Creek coal mine
- * Advise on outburst management plans for underground coal mines—ACARP project
- * Stress path analysis of Cooper Basin coal seams - Santos

2015

- * Gas drainage studies at Moranbah North coal mine and Grosvenor coal mine, QLD
- * Major consulting review of Kestrel coal mine gas drainage
- * In-situ stress testing by Sibra IST for Sydney WestConnex, NSW
- * In-situ stress testing by Sibra IST for Melbourne Metro Rail, VIC

2016

- * Continue In-situ stress testing by IST for major civil tunnelling projects in Sydney, Melbourne and Brisbane
- * Manufacture of managed pressure drilling system for Lian Tang tunnel, Hong Kong
- * Underground gasification field testing for Leigh Creek Energy, SA
- * Field testing for commercial potential of Fairhill seam at German Creek for coal seam gas for EDL, QLD
- * Comprehensive stress, permeability and gas content field program at Wambo coal mine, NSW

2017

- * Continue In-situ stress testing by IST for major civil tunnelling projects in Sydney including Sydney Metro and WestConnex, NSW
- * Comprehensive stress and permeability testing, gas content measurement and multiple seam piezometer installations at Kestrel South coal mine, QLD
- * In-situ stress testing by IST for Snowy Hydro 2.0 feasibility study
- * Stress and permeability testing at Oaky Creek coal mine, QLD
- * Comprehensive stress and permeability testing at Wambo coal mine, NSW

2018

- * Snowy Hydro 2.0 in-situ stress testing by Sibra IST and hydrojacking, permeability measurement by packer testing and then more comprehensively by DST testing
- * Snowy Hydro 2.0 geotechnical review
- * In-situ stress testing by Sibra IST for Sydney Metro, NSW
- * In-situ stress testing by Sibra IST for Narrabri coal mine, NSW
- * Supply of multiple, 10 MPa well control systems to a client in Mozambique

Research and Development

2014

- * ACARP study into outburst risk in underground coal mines
- * Development of a core barrel to collect all lost gas during extraction of core from borehole
- * Development of piezometer installations using Sibra's patented cement displacement technology to allow for isolation testing between piezometers and reduced sensor lag time after grout placement
- * Development of pulse testing to determine directional permeability, anisotropy, inhomogeneity and storativity
- * Manufacture a triaxial loading cell

2015

- * Development of alternative methods to examine mixed gas isotherms
- * Development of native isotherm measurement equipment
- * ACARP Study into coal outburst risk

2016

- * Development of triaxial testing to measure nonlinear anisotropic rock properties and poroelastic behaviour
- * Development of mathematics to describe real rock behaviour incorporating fluids

2017

- * ACARP funded research into outbursts and rockbursts
- * ACARP funded research into coal mechanical properties
- * Preliminary design of rotary steering tool for directional drilling applications

2018

- * Continued research into rock properties
- * Development of new hydrofracture stress testing system
- * Continued development of a rotary steering tool for directional drilling applications
- * Presentation to Mine Managers Association on the outcome of the ACARP study into coal outburst risk and rockbursting

Guiding Principles

Sigra is committed to providing the best possible solutions for its clients. This means that the solution must be feasible, sustainable, appropriate and economically sound, within the context of the best health, safety and environmental objectives.

Sigra owns its own technologies and will advise the client to use them where these are appropriate. It will not do this where other more appropriate technologies exist.

Defining what exists in the ground comes from the application of multiple sciences and knowledge of geology in its greater sense. Understanding the geology is the key to providing a solution to matters related to the ground.

Devising solutions to engineering problems is an art form to which there are many possible solutions. Finding the solution that works best depends on the skill of the engineers and the palette of tools they have at their disposal, and one that is not restricted by current fashions in industry.

Sigra is committed to providing its staff with a comprehensive holistic understanding of how an individual's contribution fits into the bigger picture of the client's needs and the provision of an appropriate engineering solution. Only with this broader perspective can Sigra progress through its expanding knowledge base. We therefore have a strong commitment to continuous education within the organisation. We often find this approach means that we educate our clients, and the industries they represent, as well.

Sigra as an organisation is always prepared to engage in research and development of new technologies so as to maintain its leading edge services cost effectively. This development directly benefits our clients.

Code of Conduct

TECHNOLOGY

- Sigra is an organisation committed to the highest standards in whatever we do.
- This applies equally to what we measure, how we interpret it, to the advice that we provide, and to the equipment that we build.
- We are continually on a pathway of research and development that is pushing the boundaries at all times.

ETHICS

- Sigra is committed to providing accuracy in its measurements and honest interpretations, using appropriate technology for our clients. We will not be corrupted or swayed from this path.
- We are absolutely clear about our standards, and will not allow them to be compromised, either scientifically or commercially.

HEALTH AND SAFETY

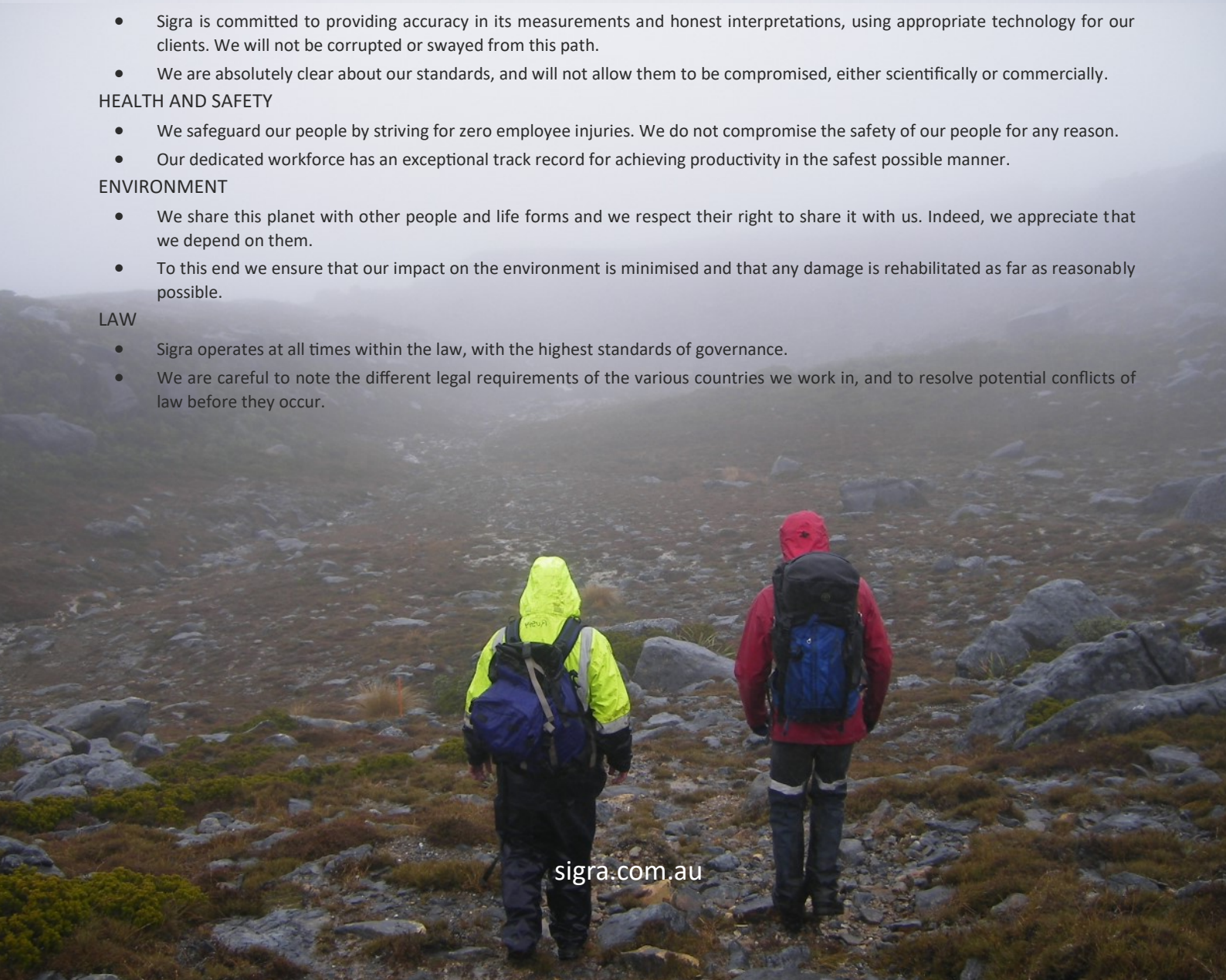
- We safeguard our people by striving for zero employee injuries. We do not compromise the safety of our people for any reason.
- Our dedicated workforce has an exceptional track record for achieving productivity in the safest possible manner.

ENVIRONMENT

- We share this planet with other people and life forms and we respect their right to share it with us. Indeed, we appreciate that we depend on them.
- To this end we ensure that our impact on the environment is minimised and that any damage is rehabilitated as far as reasonably possible.

LAW

- Sigra operates at all times within the law, with the highest standards of governance.
- We are careful to note the different legal requirements of the various countries we work in, and to resolve potential conflicts of law before they occur.



Some of Our Clients

AECOM

snowyhydro

BHP



 **Queensland Government**
Department of Transport and Main Roads



GLENCORE



coffey 

 **Transport
Roads & Maritime
Services**



GOLDER

**Sydney
WATER**

RioTinto



Centennial Coal



Santos

**South West
Pinnacle**

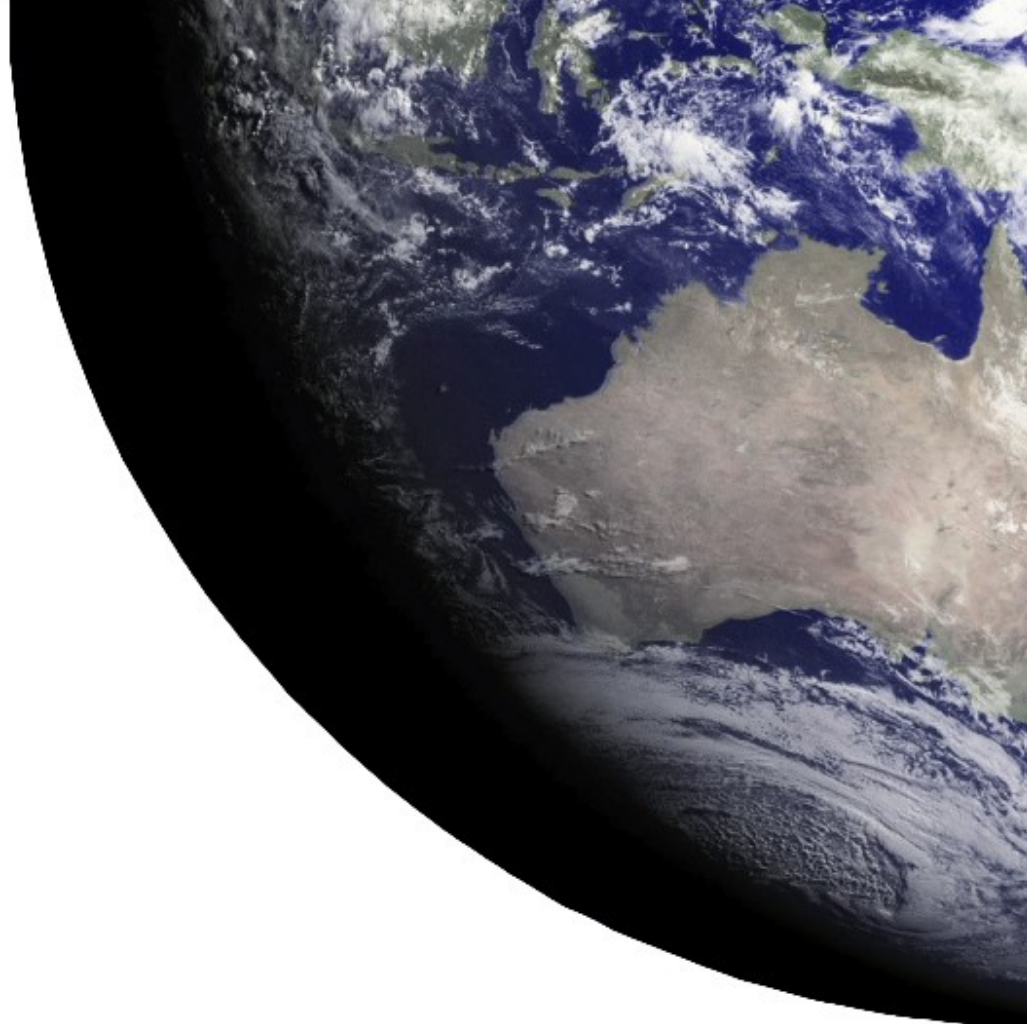


 **Agapito
Associates, Inc.**
Mining & Civil Engineers & Geologists



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For more information on our products and services, visit our website:

Sigra.com.au

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