# A SYNOPSIS OF SOME OF SIGRA'S TEST TECHNIQUES

## STRESS MEASUREMENT OPTIONS

**IST** Stress measurement in rock by overcoring using the Sigra IST tool.

**FRAC** Hydrofracture of the seam for minimum seam stress.

**BBREAK** Examination of acoustic scans for borehole breakout. This is done to build a the picture of stress over the mine or lease

**OVAL** Measurement of core ovality as an indication of difference in stress. This is preferably conducted using a Sigra coring bit and core barrel. The technique is still in the developmental stage.

**SONIC** Examination of sonic logs to determine if stress signature can be seen.

## GAS CONTENT MEASUREMENTS IN ROCK

Sigra provide four services to measure this fundamental parameter of coal seams and shales.

**DESCOR** Core desorption. Also used to provide information on the diffusion rate for use in the assessment of outburst risk and gas release from cut coal.

**GCCOR** Gas capture coring – in this all gas is captured within the core barrel.

**DESCUT** Cuttings desorption from surface drilling or underground drilling.

**GCWC** Gas content without coring – cuttings desorption with no lost gas.

## GAS ADSORPTION ISOTHERMS

**ISO** Laboratory measurement of isotherms using a single gas type by re-adsorbtion.

**NISO** Native sorption isotherms – the isotherm on initial desorption. Native isotherms are isotherm measured by putting core into a water filled pressure vessel and sealing it. The first equilibrium pressure measured is the minimum sorption pressure. Following this core is desorbed in stages to arrive at isotherm on initial desorption and the total gas content.

**NSORP** The initial pressure from a native sorption isotherm test. It represents a minimum seam sorption pressure.

## RESERVOIR / GROUNDWATER TESTING

**DST** Drill stem testing for permeability, reservoir pressure, skin, mean effective radius of investigation.
Sigra have wireline tools for use in HQ coring situations as well as tools for the end of the drill string.

**PDST** Pulsed DST testing for directional permeability.
The most economic way we know to determine directional permeability and to differentiate it from inhomogeneity is by conducting pulsed DST testing. This involves undertaking a DST test in one hole and from this calculating the mean permeability. A pressure transducer is then put into this hole (PTRANS qv) and another adjacent hole is drilled and also tested using DST methods. This enables another average permeability measurement to be made and also the directional permeability to be measured between the two holes. This process may be repeated to provide a full determination of anisotropy.

**CCDST** Closed chamber DST
Permeability measurement by drill stem test into a closed chamber. The current tool is for use with a 6 m HQ core barrel and has a volume capacity of 9 litres. It is therefore suitable for testing lower permeability reservoirs. One advantage of the tool is that it can be run without the use of a compressor to depress the fluid level in the drill string.

## RESERVOIR /GROUNDWATER MONITORING

**PTRANS** Pressure transducer installations in seam.
The concept of drilling exploration holes and then not using them for further monitoring very wasteful of resources. This applies especially when further gas content compliance cores need to be drilled. It is more useful to install continuous pressure sensing in the hole. It is also more cost effective. These installations are not just simple piezometers.

Sigra installs transducers using their cement displacement system that actually work and may be tested for their connection to the formation and against intraconnection in the borehole.

Sigra can also use swell packers to isolate zones for pressure measurement.

# MECHANICAL TESTING OF ROCK and COAL

**TRIAXB** Triaxial testing of rock and coal for poroelastic behaviour

This test process enables the determination of Young's moduli, Poisson's ratios and the poroelastic parameters for 60 to 63.5 mm diameter core. The results are calculated on the basis of orthotropic material behaviour.

**TRAIXF** Triaxial testing of rock or coal samples to failure. The output are Mohr-Coulomb or Hoek-Brown parameters.

**HYDRO** Hydrostatic testing of rock and coal where only fragments exist. This is particularly useful in determining anisotropy.

This type of testing is a second best alternative to TRIAXB.

**UNIAX** Uniaxial testing of core.

This test is primarily to determine the unconfined strength of core.

Strain gauges are attached to the core this is more for an indication of how the core behaves before failure rather than for precise values of Young's modulus or Poisson's ratio. The test is frequently performed as a cyclic test to determine the unloading behaviour of the core and to determine the difference between elastic and permanent deformation.

**TENS** Sigra has developed true tensile testing of core both in the axis of the core and on tests conducted on biscuits of core cut transversely to the core axis. The latter are particularly useful in determining the tensile strength of the rock in a plane through the bedding of sedimentary strata.

**SHRINK** Coal shrinkage behaviour on gas loss.

Coals shrink as they lose gas. This shrinkage behaviour can de-stress the coal leading to changes in permeability and also to the stored strain energy within the coal. Sigra measures swelling/shrinkage behaviour of coal.

**PROTO** Protodyakanov Index testing for toughness.

Measuring coal toughness (energy per unit volume to fracture) directly is difficult. This simple test measures how coal fragments when subject to having a drop hammer weight dropped on it. The result is an index value which is related to the toughness of the coal.

**POP** Pop-Gun tests for fragmentation on sudden desorption.

This test determines how coal fragments under sudden desorption.

It involves absorbing gas into coal and then suddenly desorbing it.

The results are important in the context of outbursting.

**CARB** Carbonate content – matrix and cleat

The presence of carbonates dramatically changes the permeability of Coals. It can also change their mechanical properties by healing fractures. The determination of carbonate content in the matrix and in the cleats is an important indicator of how serious this problem may be. Sigra tests for matrix and cleat carbonate separately.

**STRUCT** Structural examination of coal core.

The way in which coal fractures can be frequently determined by the pre-existing structure within it. To determine this Sigra take coal lumps, or preferably core, section it and polish it on several planes and examine the fractures that exist within it. This forms basis for basis for determining how coal will break.

# SOME OF SIGRA'S ANALYSIS TECHNIQUES

Sigra use few of the standard analytical tools of the industry. The reason for this is that many of these have been found wanting. Sigra does still use SIMEDWin for simulation of gas flow in coals. Despite some limitations it is still useful. Sigra also has its own simulator. Sigra also uses commercial finite element software with some modifications in stress-strain analysis.

Sigra also has some quite specialised analytical techniques of its own. A few of these are described below.

## Stress Distribution (STRES)

Most of the sedimentary areas that are studied have stress distributions that are caused by gravitational load and subsequent tectonic strains imposed on the rock mass. These strains are usually relatively uniform while the stresses tend to vary with their stiffness. Sudden jumps in tectonic strain are generally brought about by unconformities or by faulting. In conducting stress distribution studies all information needs to be taken into account, including overcore measurements, any hydrofracture information, borehole breakout data, faulting information and sonic velocities. The complicating factor in coals is what shrinkage has already occurred due to gas and water loss.

## Stress Path (SPATH)

The stress path is the calculation of the changes in stress brought about by drainage. This is dependent on the initial stress estimation, the material properties and the changes in fluid type and pressure. Typically this would require information from:

- Stress measurement (IST, FRAC, BBREAK)
- Material Properties (TRIAXB, HYDRO, UNIAX, SHRINK)
- Gas content (DESCOR, GCCOR, DESCUT, GCWC)
- Sorption pressure (NISO)
- Reservoir Pressure (DST, PTRANS)

Figure 1 shows a model of how sorption pressure, stress and strain behave with a reduction in reservoir pressure. The case is of a mixed gas ($CO_2$ and $CH_4$) in a coal seam with highly directional stress. The sorption pressure remains constant until the reservoir pressure drops to 3.0 MPa whereupon desorption commences. The major effective stress (blue line) increases slightly as the reservoir pressure drops below the sorption pressure whereupon the effects of shrinkage dominate leading to a declining value of stress. The minor principal stress (orange line) shows a similar trend until the stress becomes zero at 1.5 MPa reservoir pressure. As the development of tensile stress is unlikely additional shrinkage is reported as tensile strain (yellow line). This model indicates that the cleats will actually open due to continuing shrinkage. The result is expected to be a major increase in permeability with one direction becoming much more permeable than the other.

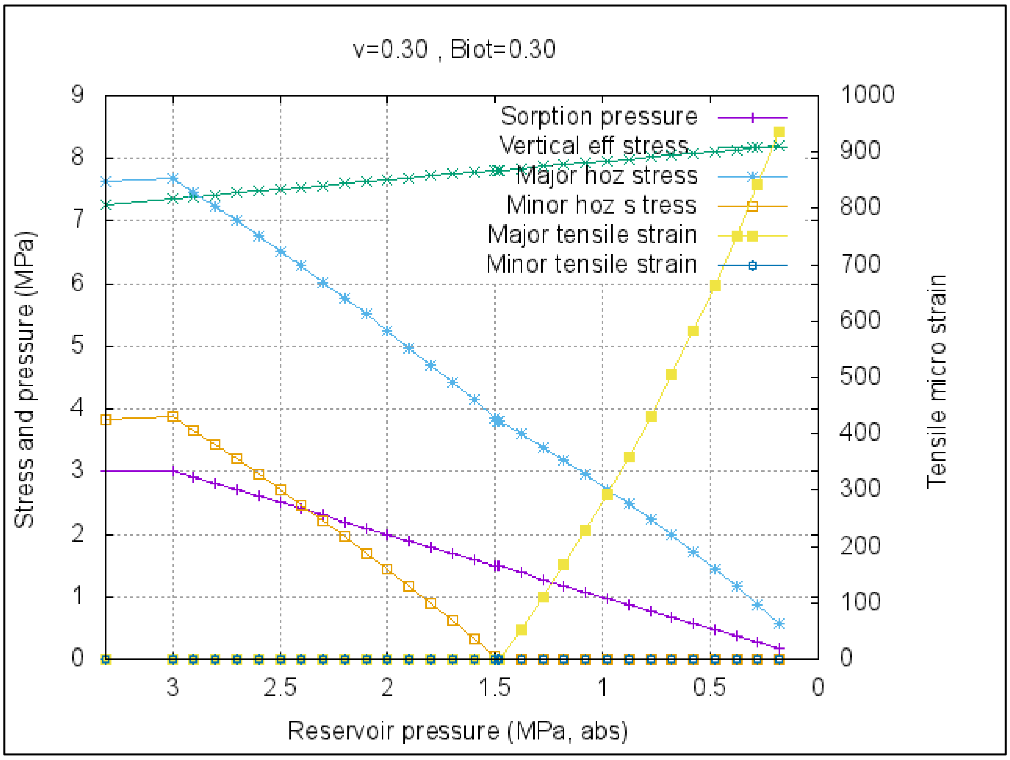


**Figure 1. Example of Stress Path for a Coal Seam**