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Wulanchabu UCG site data-status report

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Disclaimer

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Wulanchabu UCG site data-status report

SMS Project SMSE.1.10
Jeff Wagoner

This report documents work accomplished under SMS Project SMSE.1.10 relating to the Wulanchabu China underground coal gasification (UCG) site. Geophysical data were for this site were obtained from the ENN company, and we created an EarthVision geospatial model (3-D geological map) of this site.

During FY10 In April, 2010, LLNL received technical information from ENN on the Wulanchabu UCG project in the form of EXCEL spreadsheets, Word documents, Powerpoint presentations, .pdf, and CAD format (.dwg and .dxf) files. Lithology data were made available for about 30 boreholes. The well construction data included both collar and downhole coordinates. The coordinate system was not familiar to any of us at LLNL and may in fact be a local Chinese coordinate system. Since we are not using geologic data outside of the UCG site, we simply utilized this local coordinate system. Additionally, several plan maps of the site were furnished, which included digital coordinates.

A 3D lithofacies model was constructed using the lithologic logs for the boreholes. This lithofacies modeling was done using Earthvision. The lithologies included basalt, sandstone, mudstone, siltstone, coal, and conglomerate (which was not used in the modeling). The lithofacies model ranges are x=240m, y=175m, z=330m. Lithologic information from 21 boreholes was used in developing the spatial correlations.

To adequately characterize a site for assessing UCG monitoring technologies, we require specific data from the site, including well locations and total depths, directional surveys of the wells, stratigraphic and lithologic data from the wells, physical property data for the coal and overburden rocks, depth to the static water level, and geophysical logs. We received some of these data, but additional information are required. A 3D seismic reflection survey has been fielded at this site, but it is not known whether we will be able to access structural interpretations from this survey. It is hoped that additional site data will be obtained in FY11.

Figures 1 and 2 show representative views from the Earthvision lithofacies model (3-D geological map) that we created for the Wulanchabu UCG site. Figures 3-7 show examples of some of the key geologic data obtained from ENN on which our Earthvision model of the site is based.

Appendix A contains the balance of geophysical data received from ENN for their Wulanchabu UCG site.

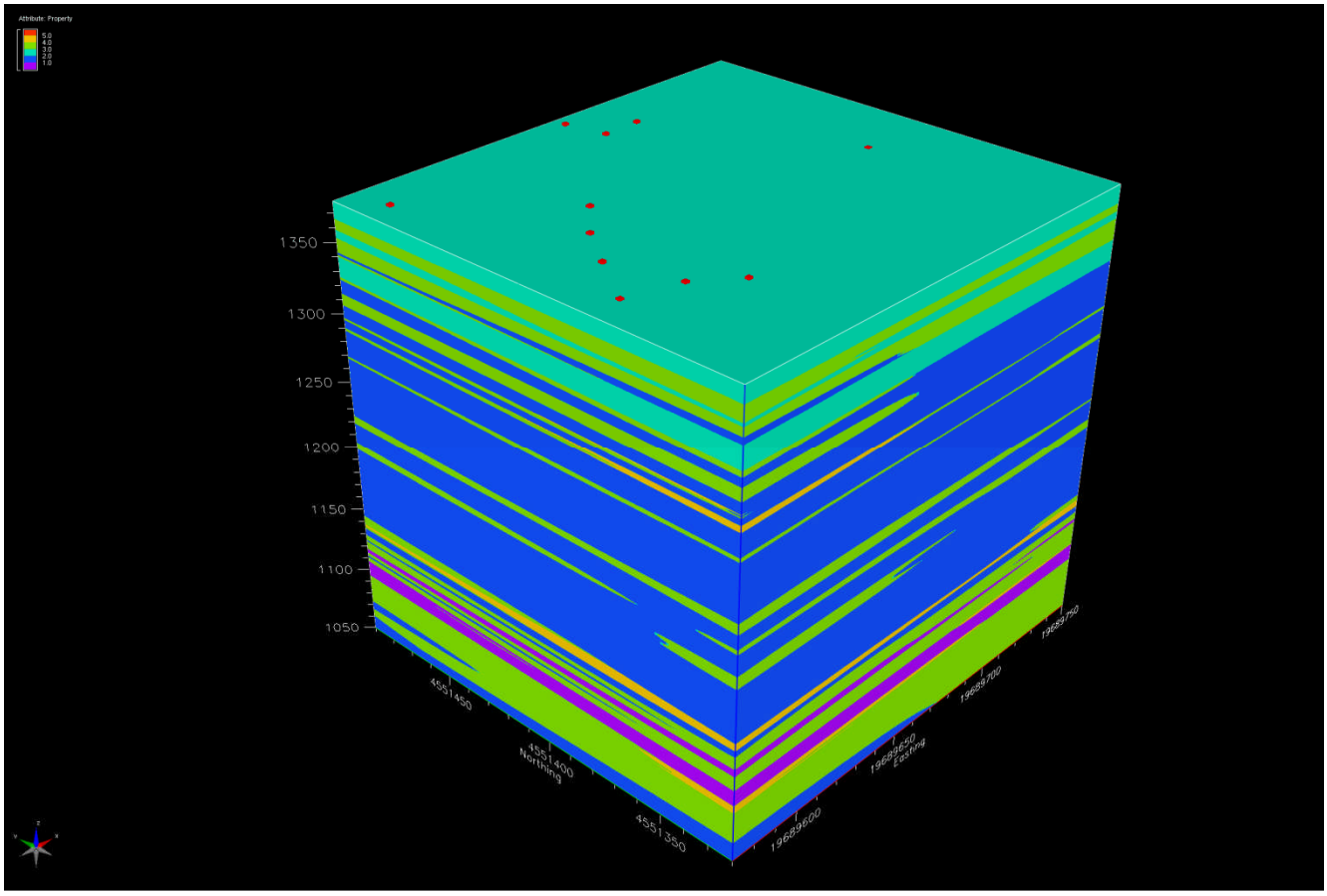


Figure 1. Preliminary lithofacies model at Wulanchabu. Purple beds are the coal. The coal is capped and underlain by mudstone (light green). Most of the section is siltstone/sandstone (dark blue). The section is capped by 3 basalt flows (light blue).

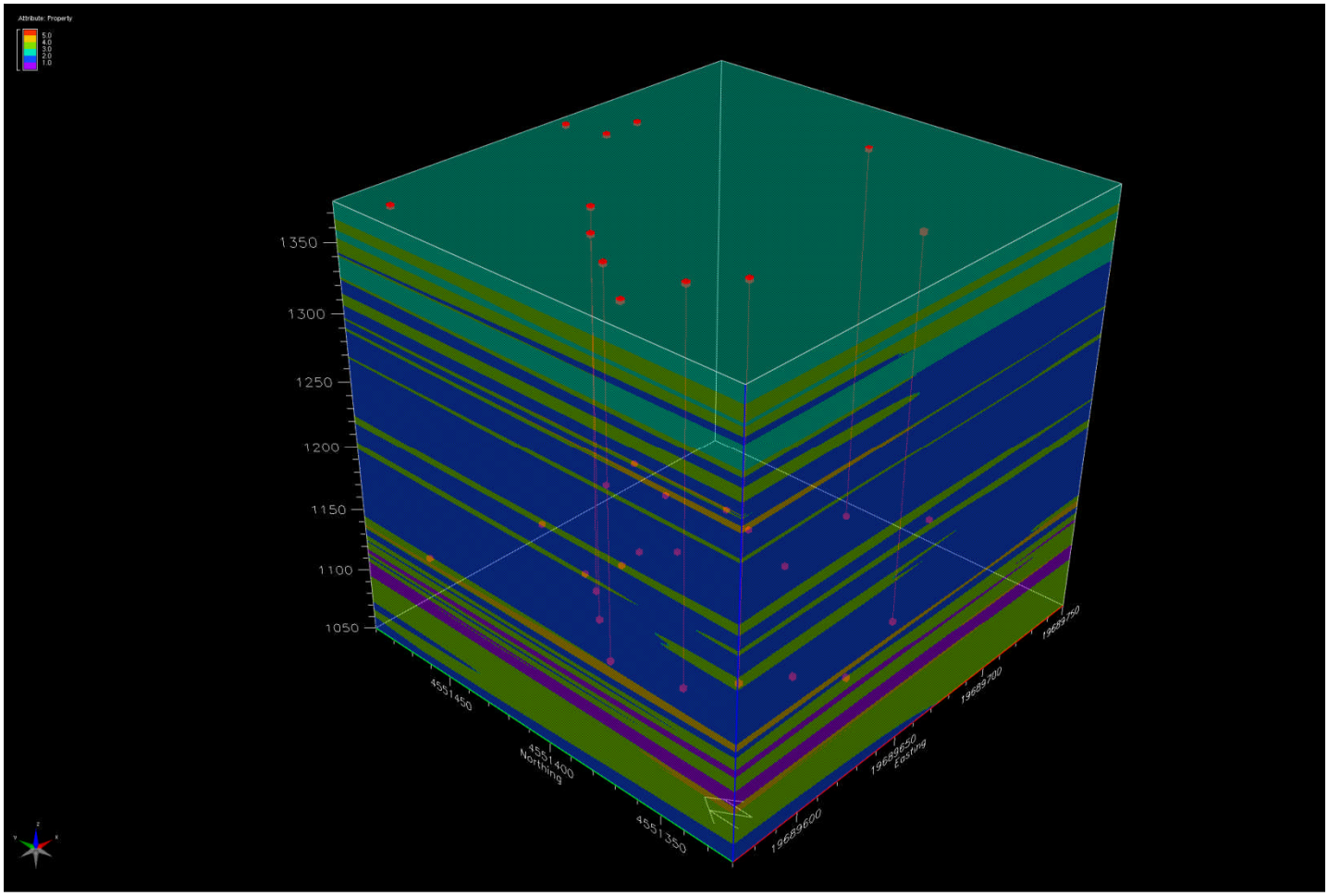


Figure 2. Preliminary lithofacies model at Wulanchabu. Transparent model allows you to view wells.

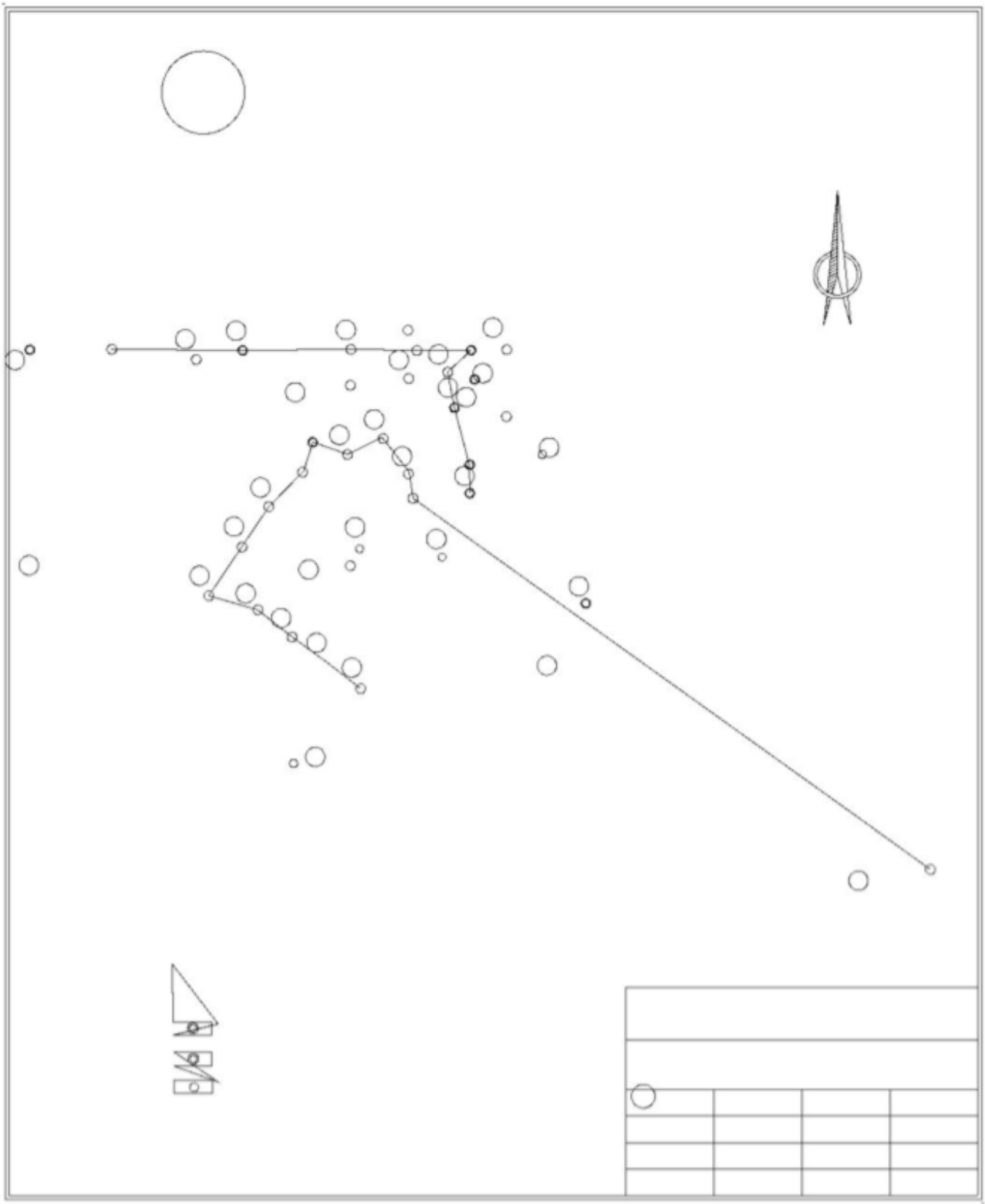


Figure 3. Wulanchabu plan map showing well layout (as sent to us by ENN).

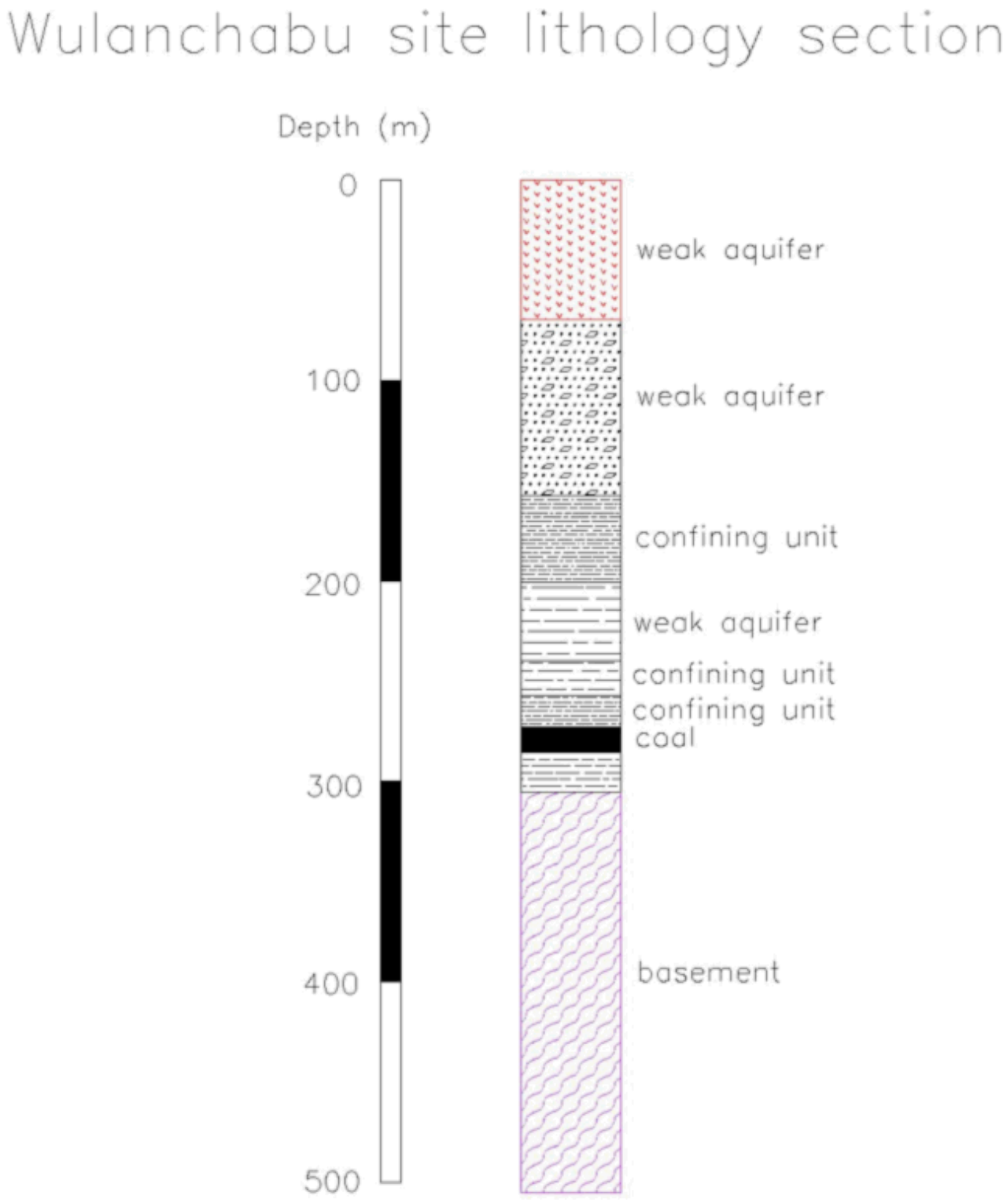


Figure 4. Detailed stratigraphy of basin at Wulanchabu.

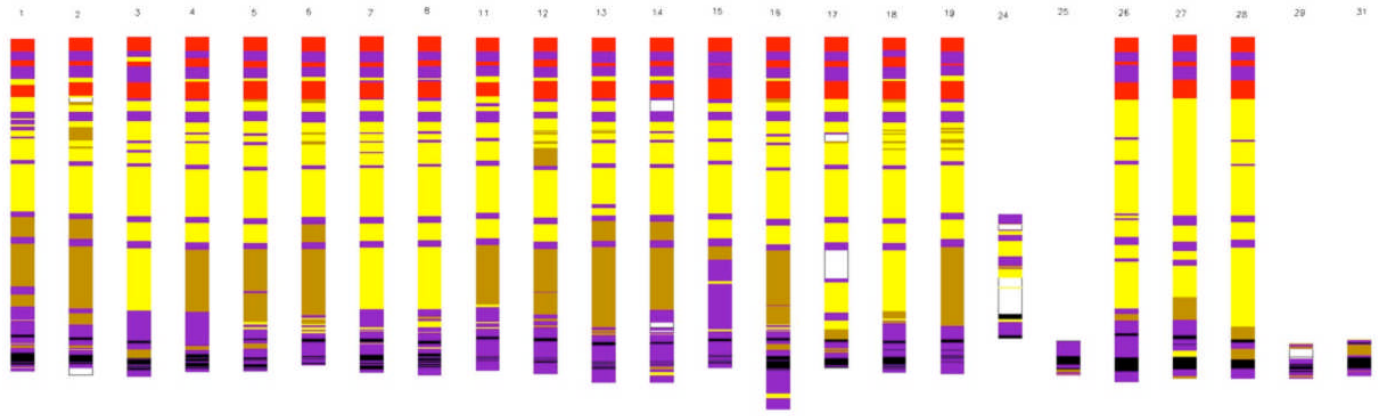


Figure 5. Lithologic columns for all of the wells at the UCG site. Well numbers are listed at the top of each column. Color scheme: basalt (red), sandstone (yellow), siltstone (tan), mudstone (purple), coal (black).

Figure 6. Example of the detailed lithology of one of the wells. Note the 3 basaltic flows at the top of the section.

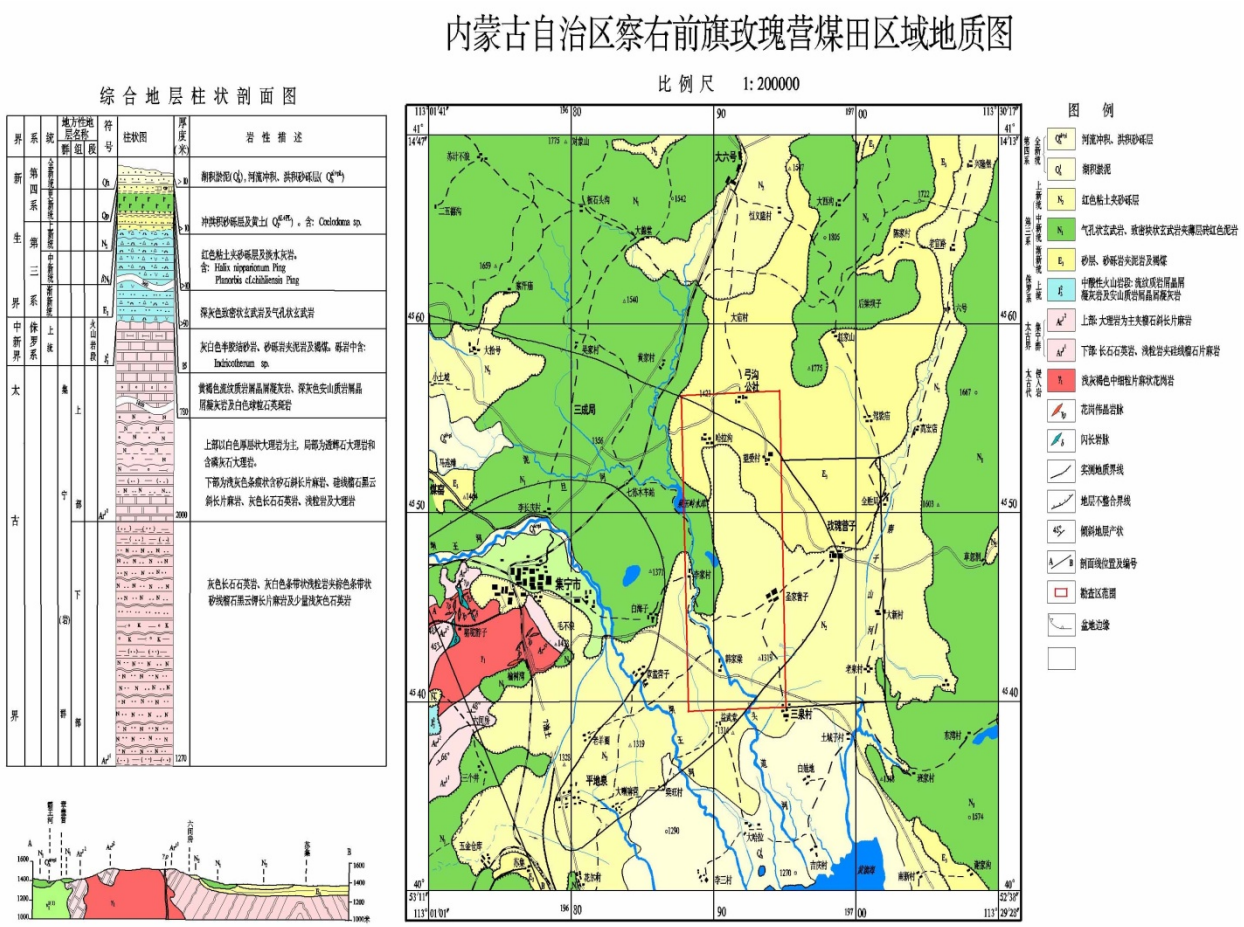


Figure 7. Geologic map of the Wulanchabu area (from ENN).

Appendix A. Data archive of ENN technical files

Note that he following tables, text, and figures are taken directly from the files that ENN sent to LLNL. At this point, we have made no attempt to clean up the text and the tables. These are being included so that are relevant data that we have received from ENN are documented in one place.

Table 1. Regional Stratum Abridged Table

Erathem	System	Series	Group	Formation	Member	Code	Lithology	Thickness（meter）
Cenozoic Erathem	Quaternary System	Holocene Series				Qhal+pl	Fluvial alluvium、Diluvium hardpan	> 10
						Qhl	Lacustrine silt	> 10
	The Third System	Pliocene Series				N2	Red clay and hardpan	> 10
		Miocene Series				N1	Celadon, black compact massive basalt, taupe, pore basalt, maroon and brick red mudstone, Yellow and buff sand stone	> 90
		Oligocene			Ascending Membe	E32	Mottle French grey sand	> 50

		Series			r		conglomerate, conglomerat Figure e, component to be granite and gneiss，accidentally coal line.	
					Descending Member	E31	Light gray, grayish color, brick red fine sand block, sandy clay, clay. ragstone and sand conglomerate，accidentally coal line.	> 90
Mesozoic Erathem	Jurassic System	Ascending Series			Volcanic Rock Member	J32	Rhyolite bore meal crystal fragment tuff and andesite bore meal crystal fragment tuff.	1000
Archeozoic			JiNing group		Ascending Member	Arj2	Marble garnet plagioclase gneiss，	> 2800
					Descending Membe	Arj1	Feldspar quartzite，gneiss, silicon	> 1200

					r		**line garnet potash feldspar gneiss immingle Feldspar quartzite.**	

Structure

The exploration area and peripheral region's geology structure is very simple. Have never seen to fracture, fold also doesn't develop, is mainly the small fold that in archaeozoic metamorphic rock stratum.

The working quarter is located in the central part toward the complicated structure in Yin Mountain, the transition zone from the mountainous area to the basin. In point of current work degree, have something to do with JiNing basin coal series stratum tectogenesis mainly has two periods. The first one is the fore Sinian Period tectogenesis, it makes the stratum deterioration to the utmost. Stratum gneissosity mainly present northeast east strike and settled foundation for the formation palace of intermountain. The third period's containing a coal rock association, rock assemblage is swell up an area coal seam a sedimentation thinner or have no coal sedimentation, but deposit at the hollow area coal seam opposite thicker.

The second one is a Cenozoic Era orogeny (Himalayan orogeny). The basin of Cenozoic Era distributes north northeast in the region, then belong to a Neocathaysian structural system. The orogeny is accompanied by basic basalt eruption. As a result, it made the bigger basin divided into small sags. Inside basin main is the land lagoon facies clastic rock sedimentation, the third system Oligoncene Series (E3) become coal age. The influence of this orogeny upon the coal seam is smaller in regard to that coalfield and become in the partial thickness of coal seam of hollow area thin or have no coal sedimentation should at the unbalance of the then vegetation and marsh, bog, swamp growth relevant.

Igneous rock

As a whole, exploration area and its peripheral area's magma activity is weak. There is intrusive rock of archaeozoic outcrop in the western of working area, its lithology is the taupe, granule, gneiss granite. The rock mass is basic to

present northeast east to distribute, the area presents more regular stock form to produce about 30 Km^2. Himalayan orogeny magma activity is mainly basalt, which can be find in the exploration area and it peripheral area's. The vein rock is mainly the granite pegmatite, and the diorite is in the second place.

Exploration area Geology

Exploration area Stratum

Earth's surface is covered by the Quaternary System stratum. There is jot the third system a basalt nudity in the west and northeast of the region. The stratum contain a coal of Oligocene Series top member (E_32) basset only in northeast and central part to be partial to east of the Exploration area. The coal seam has no basset, for cover up type mineral deposit. Now according to the earth's surface and the drillhole, borehole acquisition get of date from old go lately summarize as follows:

The bottom of the medium archaeozoic JiNing(rock) group (Arj2)
It can't be seen in the earth's surface.

The boreholes of this area appear to be the bottom of the medium archaeozoic JiNing (rock) group (Arj2), which is the basement of the coal stratum,202.95 meters(4 line ZK401 holes) to 565.25 meters(1 line ZK304) apart from the earth's surface. Relative elevation is 363.3 meters, present an intermountain not flat. It can be seen in the ZK103, ZK204, ZK302, ZK303, ZK304, ZK401, ZK402, ZK403, ZK502, ZK602, ZK603, ZK701, ZK702, ZK801, ZK802, ZK803 etc. 16 boreholes. Mainly see the migmatite turn granite, garnet gneiss and garnet hornblende gneiss, the rock has different degree eclipse to change (the carbonate turn, kaolinization etc.) thickness not pure, borehole the most thick 32.30 meters.

The third system.

1. Oligocene Series (E3)
It is divided into two rock members:
(1)Descend member (E31):
It can't be seen in the earth's surface. But it can be seen in each borehole, is the main coal stratum in the exploration area, directly overlay on the basement. The ZK101, ZK602 sees gastropods and plant fossil.

The lithology mainly is French grey- charcoal gray siltstone, mudstone and medium-the tiny particle feldspathic quartz sandstone, mudstone and medium-the thick grain feldspathic quartz sandstone, ragstone and gravel rock. The color of rock becomes deeply to charcoal gray or ash black.

It is Mud quality and Calcium quality cementation. See multilayer lignite, the most is eight layers (ZK801). There are two minable coal seams in a great measure. One minable coal seam in part. All remaining are not workable coal seams.

The coal slack is mainly a deep gray- gray and the black contains char scraps mudstone. The minimum thickness is 36.23 meters, the most thickness is 257.01 meters, and the average thickness is 157.28 meters. Basal conglomerate can be seen in some part. This stratum is at the most thick in the central part to be partial to a north (3 lines) in the exploration area. And the coal seam is opposite thick and stable. Northwest and southwest are take second place, and the coal seam is asymmetry. The southeast is in the last place, but part endow with minable coal seam. A unconformity contact with the next prostrate stratum.

According to the borehole date, combining the profile comprehensive research, we establish the stratum sequence as follows:

(From new to old)

(2)Last member (E32):

The stratum's earth's surface is a little outcrop in the northeast and central part to be partial to east of the exploration area. It can be seen in each borehole. And the stratum is mainly composed of mauve, lark, mauve siltstone, medium-thick feldspar quartz sandstone, medium-thick feldspar quartz sandstone containing a cobble, mudstone or mudstone containing a cobble. Pebble rock or breccia can be seen in some part. The minimum thickness is 143.64 meters, the most thickness is 463.18 meters, average the thickness be 263.18 meters. The most thin is in the central west of the exploration area, to on all sides increase gradually, the most thick place is the borehole ZK803 surroundings, with next prostrate stratum Oligocene Series to descend a member(E31) to present negative related relation.(see illustration).

2. Miocene Series(N1)

The earth's surface of Miocene Series (N1) has jot to distribute in the west and northeast. It was not seen in greatly part of boreholes. The upper part is the taupe pore basalt, or iron grey basalt. The central part is the mudstone, part for

siltstone and mudstone (Have never seen animal or plant fossil). The lower part is amaranth taupe pore basalt. Part of it is celadon collapse massive basalt. The minimality of the controlled thickness is 3.57 meters, the most thickness is 96.39 meters and the average is 43.29 meters. Contact with the next prostrate stratum unconformable.

3. Pliocene Series (N2)

It can't be seen in the earth's surface, distributing partly (only in 6 boreholes).The lithology is lark sand and claypan. The minimum thickness is 10.16 meters (Central part to be partial to the east ZK401 borehole in the exploration area). The maximal thickness is 30.13 meters (The north to be partial to the east ZK104 borehole in the exploration area).The average is 18.64 meters. Contact with the next prostrate stratum unconformable.

4. Quaternary System Holocene Series (Q4)

Distribute scope in ore district the south bigger. The upper part is humic layer. The most is sand layer and sand gravel layer. The minimum thickness is 0.8 meters and the maximal thickness 75.8 meters, the average thickness is 16.03 meters. Contact with the next prostrate stratum unconformable.

Structure

We didn't see a structure in the exploration area. Workaround is in the central part of the horseshoe form monocline structure of the northeast and the southeast plunge at the basic appearance (See the regional geological map). The occurrence of the coal seam is nearly to level, it is a simple monocline which is slowly tilts to one side. The ore district basement undulation greatly. The biggest fall is 362 meters. From the region geological structure development to see, the work area is placed in rise over a long period of time of denudation phases from the Archaeozoic. This make Paleozoic Era and Mesozoic Era stratum greatly parts of stratum imperfection.

Magma rock

Magma rock in the ore district is top the third system Miocene Series basalt. Distribute in the west and northeast of ore district where there is a little outcrop. The magma rock overlay at the bottom of the third system Oligocene Series. According to the observation of the earth's surface and disclose of the boreholes, the basalt of the ore district can be divide into two eruption

gyrations. There is brief cease in the interval. Deposite one mudstone, the part is a silt quality mudstone, mud quality the mezzanine of the siltstone.
See from the lithology, the first gyration's color generally presents a taupe or gray, the upper part presents a pore form and almond form. The filling is calcite in the pore. The lower part gradually changes into a collapse massive and the color becomes deeply. This gyration's thickness is n meters, average n meters. Its thickness variety regulation is that toward the south from the north, it gradually become thin. The second gyration's color is generally black, iron-gray. It is collapse massive and the pore is doesn't develop well and the specific gravity is bigger. This gyration's thickness change from n meters to n meters with an average n meters. Its thickness variety regulation is that toward the southwest from the northeast, it gradually become thin. The basalt is generally higher in distributing geography, present a terrace form which protects the coal seam from efflorescence and denudation.

Coal seam

Coal containing stratum and its coal-bearing property:

The Rose Camp coalfield's stratum is mainly lower part of the third system Oligocene Series (E31). The total thickness of the mine field average 99 meters or so. Contain the coal seam from 1 to 4. The total thickness of the single project containing a coal seam is 6.24-14.15 meters, average 11.93 meters. Coal-bearing coefficient is 6.53-21.51 %, average 12.04%.

Table 2.

Bore hole number	coal seam number	coal seam pure thickness (meter) / Refuse thickness (meter)	coal seam total thickness (meter)	coal measures stratum thickness (meter)	coal-bearing coefficient (%)	remark
ZK3-1	1	3.08	13.68	99.50	13.75	
	2	0.35				
	3	$\frac{10.25}{2.03}$				

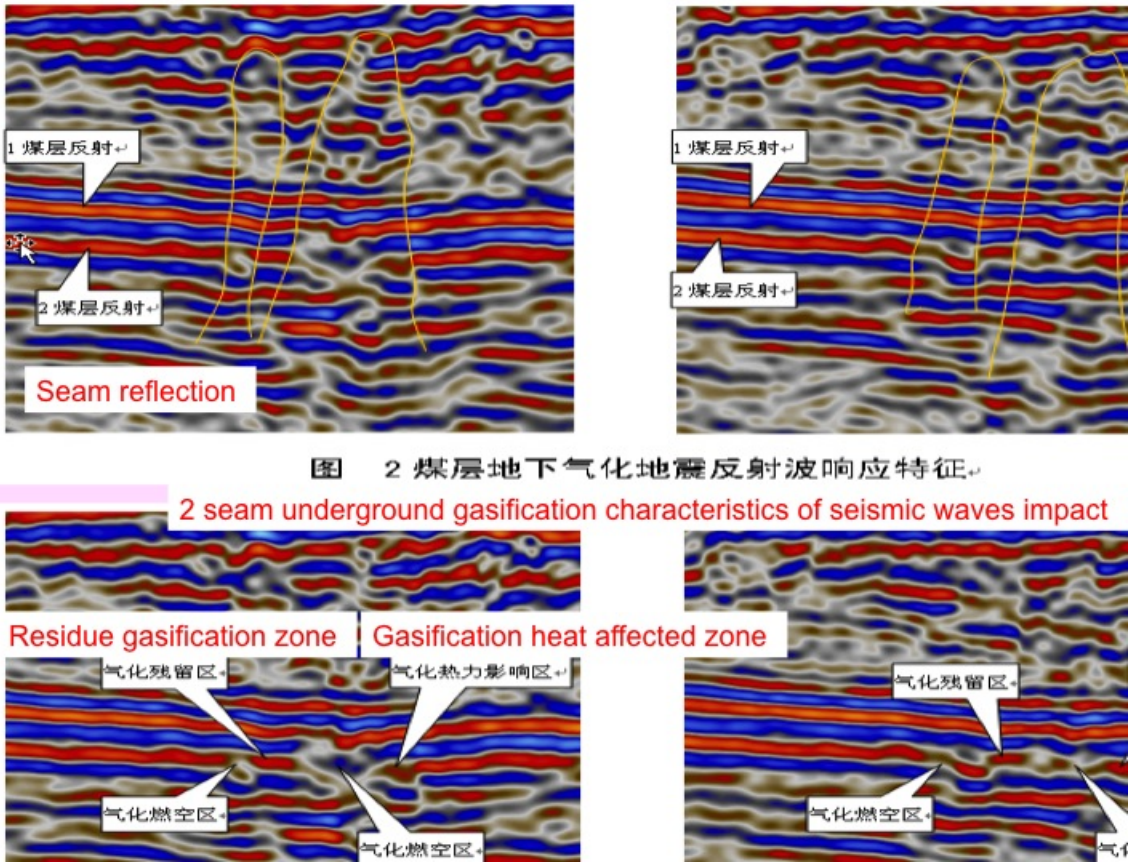
ZK3-2	1	3.0	13.18	83.81	15.73	
	2	0.25				
	3	$\frac{9.93}{2.92}$				
ZK3-3	1	2.9	14.08	65.45	21.51	
	2	0.4				
	3	$\frac{10.78}{1.62}$				
ZK3-4	3	$\frac{14.15}{4.70}$	14.15	103.35	13.69	
ZK301	1	3.05	11.62	177.95	6.53	
	2	0.50				
	3	$\frac{8.07}{3.92}$				
ZK3-5	1	2.44	12.9	89.2	14.46	
	3	$\frac{10.46}{2.20}$				
ZK3-6	1	0.24	10.18	129.2	7.88	
	3	$\frac{9.94}{2.57}$				
ZK3-7	1	$\frac{1.80}{0.55}$	11.3	83.59	13.52	
	2	0.25				
	3	$\frac{5.10}{0.95}$				
	4	$\frac{4.15}{1.95}$				
ZK3-8	1	$\frac{6.24}{1.96}$	6.24	59.71	10.45	

The following are slides extracted from a Powerpoint presentation by ENN:

- B、Design in the southern of 0.8km^2 region have18 superposition, CDP for the 5 × 5m grid three-dimensional Observation System - 12 line 18 fabricated three-dimensional observation system wiring harness.
- Specific parameters of the observing system ：
- Receive Pitch ： 10m;
- Receiver line spacing ： 30m;
- Gun dot pitch ： 110m;
- Gun pitch ： 10m;
- CDP grid ： 5m×5m;
- Receiver array ： 12 lines (66 receivers per line);
- Receiver channel number ： 792 channels;

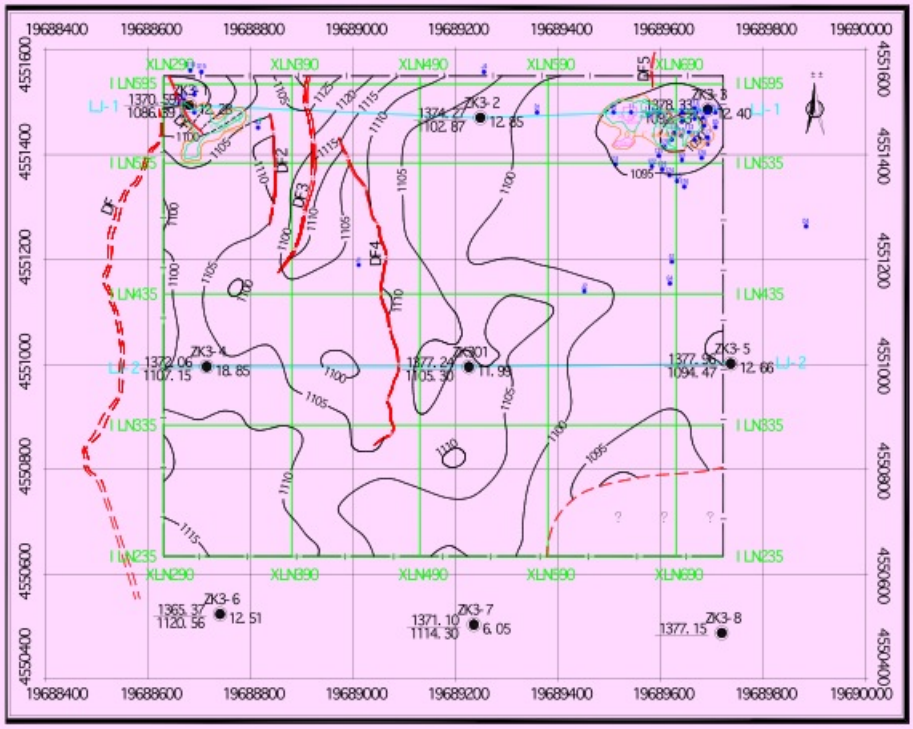
1、Seismic survey acquired in the area shooting depths, excitation and receiving factor dosage results ,decided according to the results measured in the region, using 2kg of the drug ,excitation in the 3 ~ 4m wells for better results . Collection system：

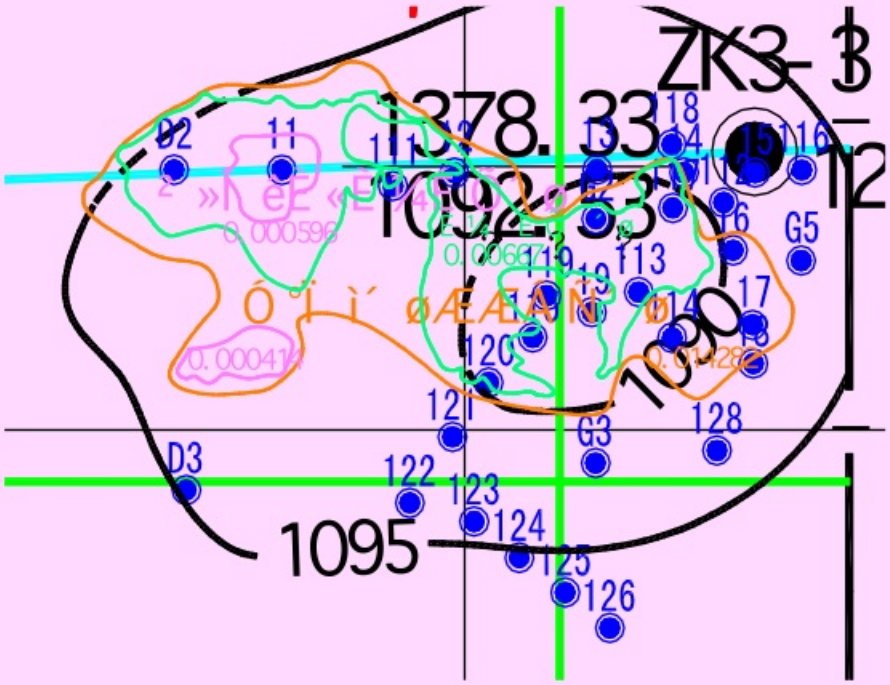
- A、In the northern of 0.2km^2 area have 18 superimposed, CDP is 2.5 × 2.5m grid three-dimensional observation system ——12 Line 36 pairs of fabricated three-dimensional observation system wiring harness。
- Specific parameters of the observing system：
- Receive Pitch： 10m;
- Receiver line spacing： 30m;
- Gun dot pitch： 55m;
- Gun pitch： 5m;
- Min-offset： 2.5m;
- Max-offset： 430m;
- CDP grid： 2.5m×2.5m;
- Receiver array： 12 lines (66 receivers per line);
- Receiver channel number： 792 channels;



Coal gasification cavity, residual damage zone and heat affected zone of seismic reflection wave response characteristics 2 seam underground

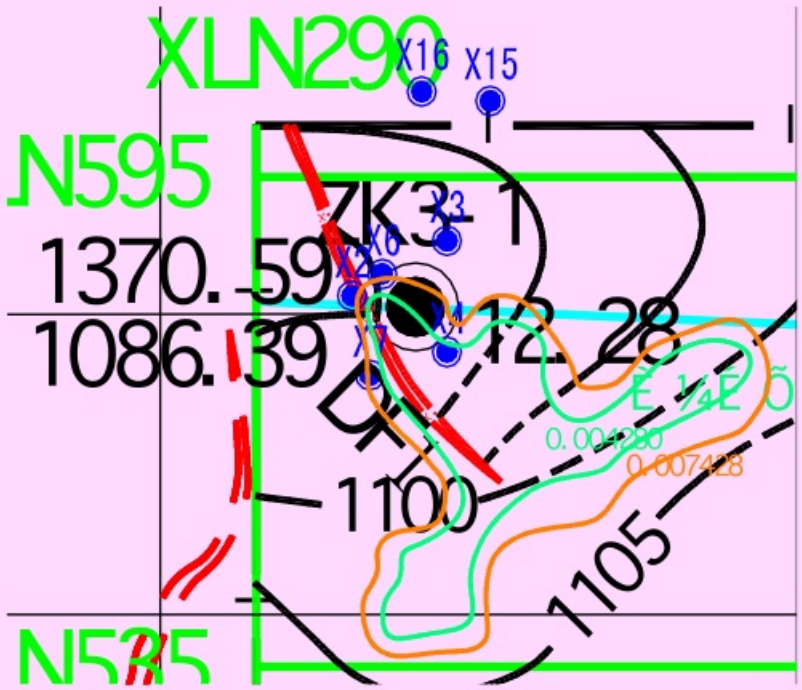
2 # coal seam floor contour and the burned-out area layout graphic bind





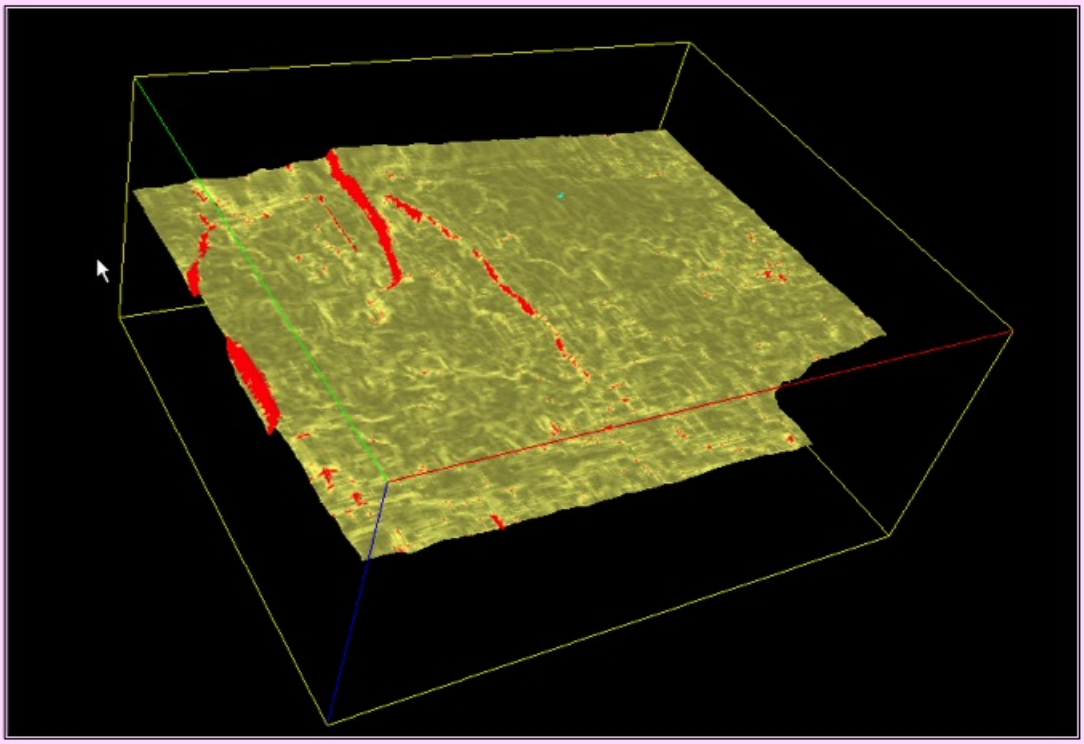
The layout plane bind of first district burned-out area

The layout plane bind of third district burned-out area

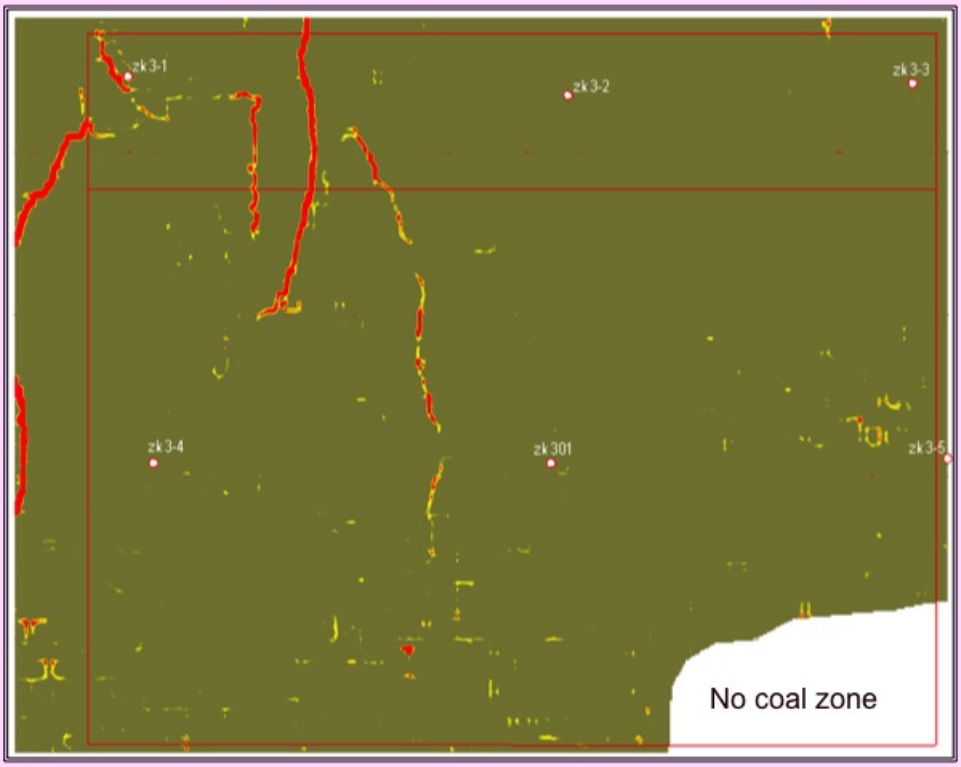


3、Identified 1km^2 fissures within the background of coal seam fractured zones, and identify the main development direction, and plot the direction and development of coal seam fracture plane with distribution maps.

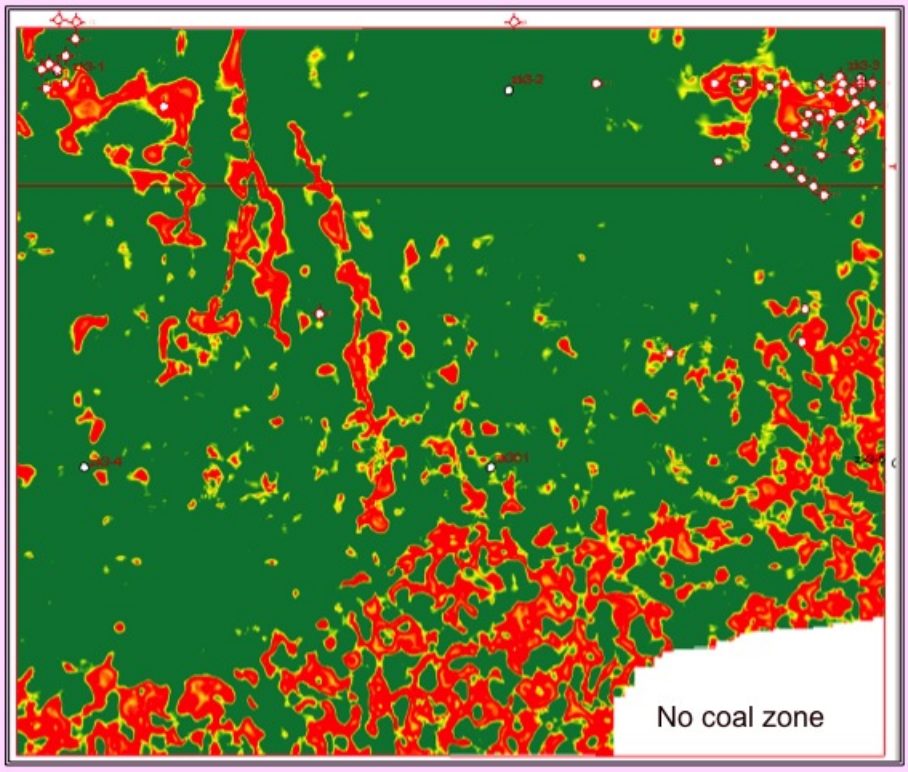
Three-dimensional seismic structure of a depth slice map crack



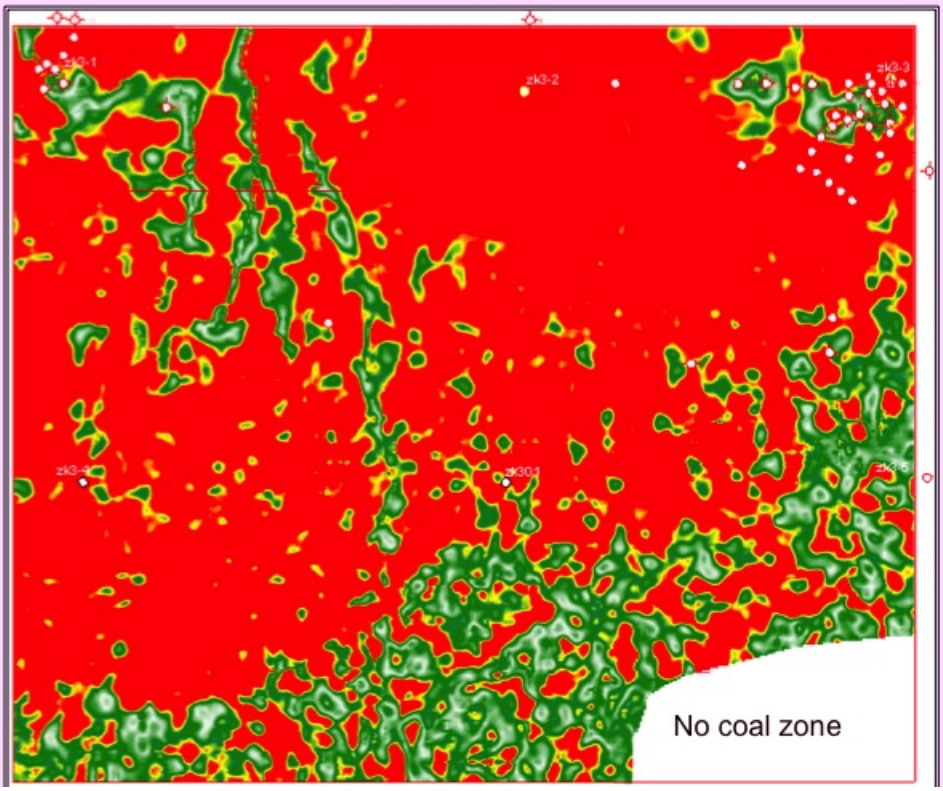
Dip 2 coal seam faults detected seismic attribute analysis chart



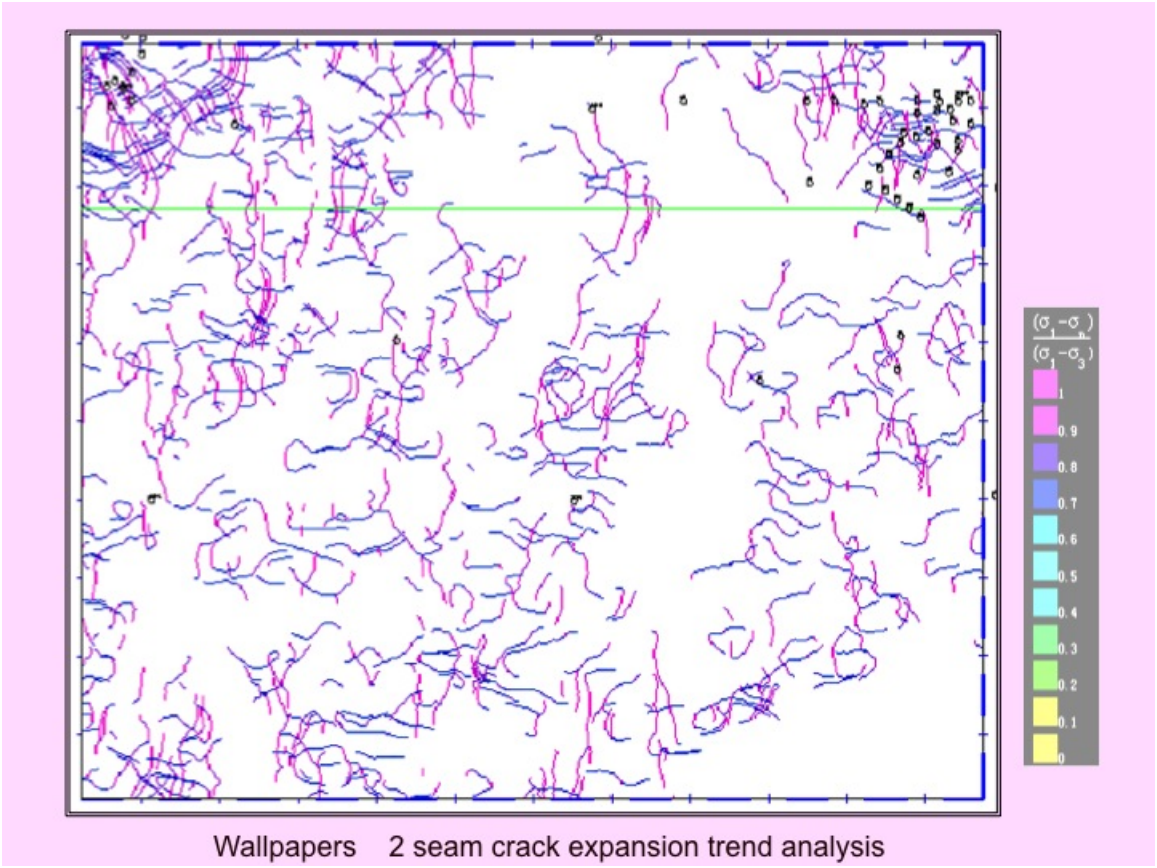
2 seam underground gasification combustion combined with the amplitude of seismic attribute analysis chart



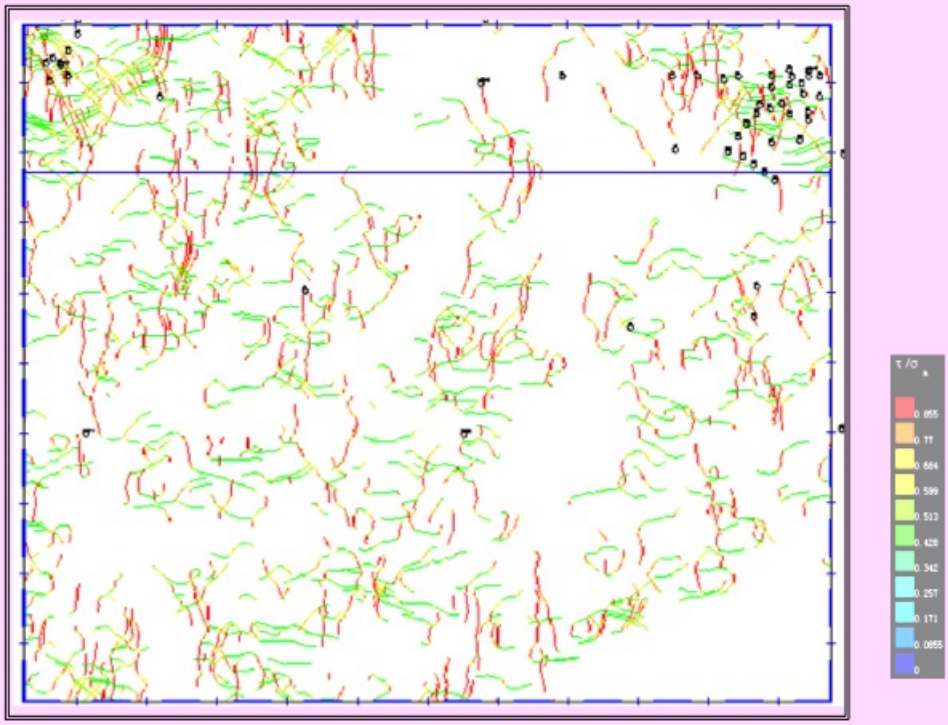
2 coal gasification thermal effects, destruction of transient amplitude seismic attribute analysis chart



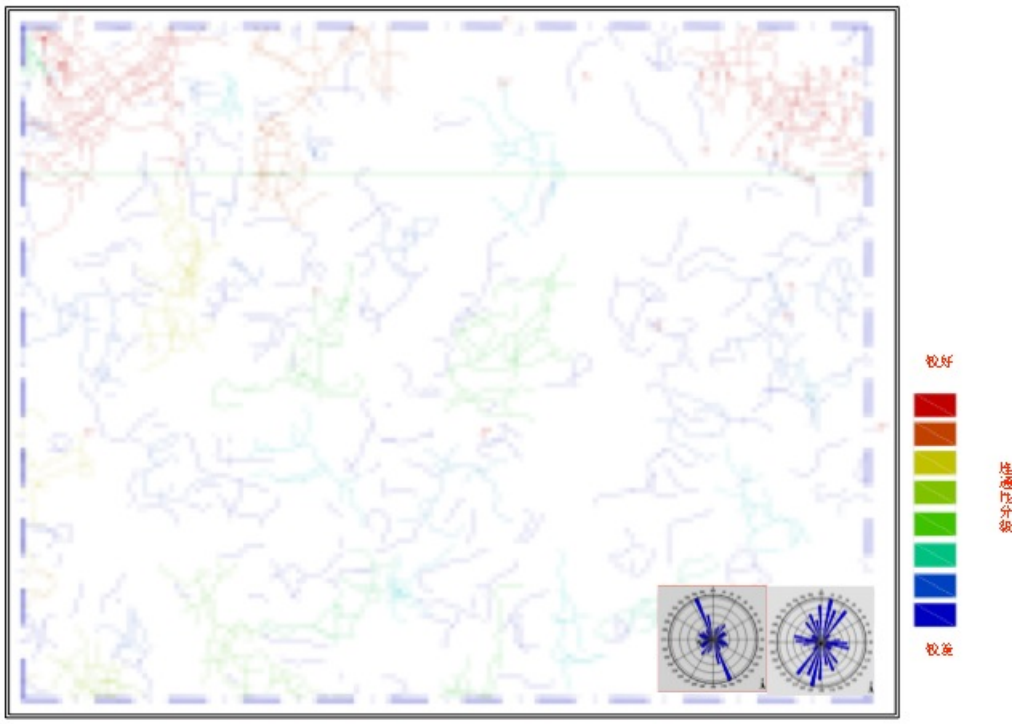
2 coal gasification thermal effects, destruction of transient amplitude seismic attribute analysis chart



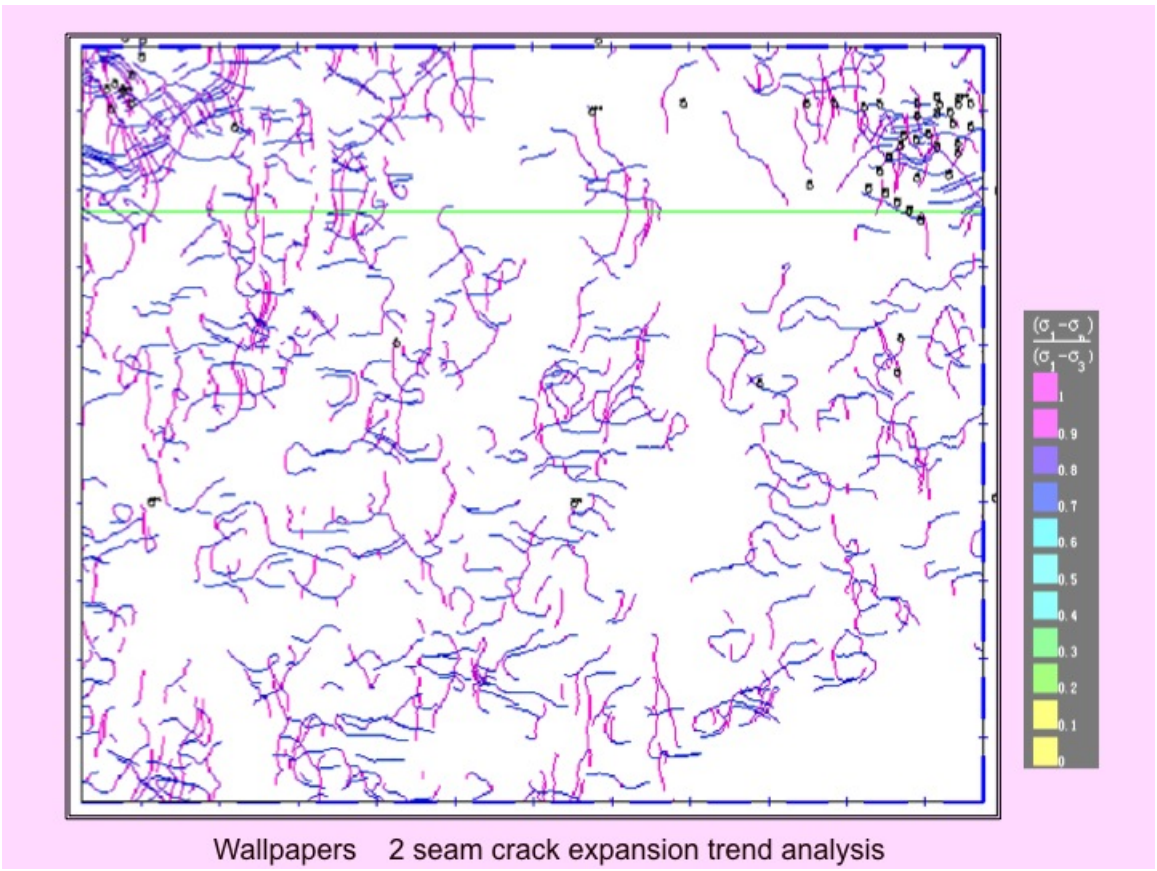
Wallpapers 2 seam crack expansion trend analysis



Wallpapers 2 seam crack sliding trend analysis
Shear stress / normal stress

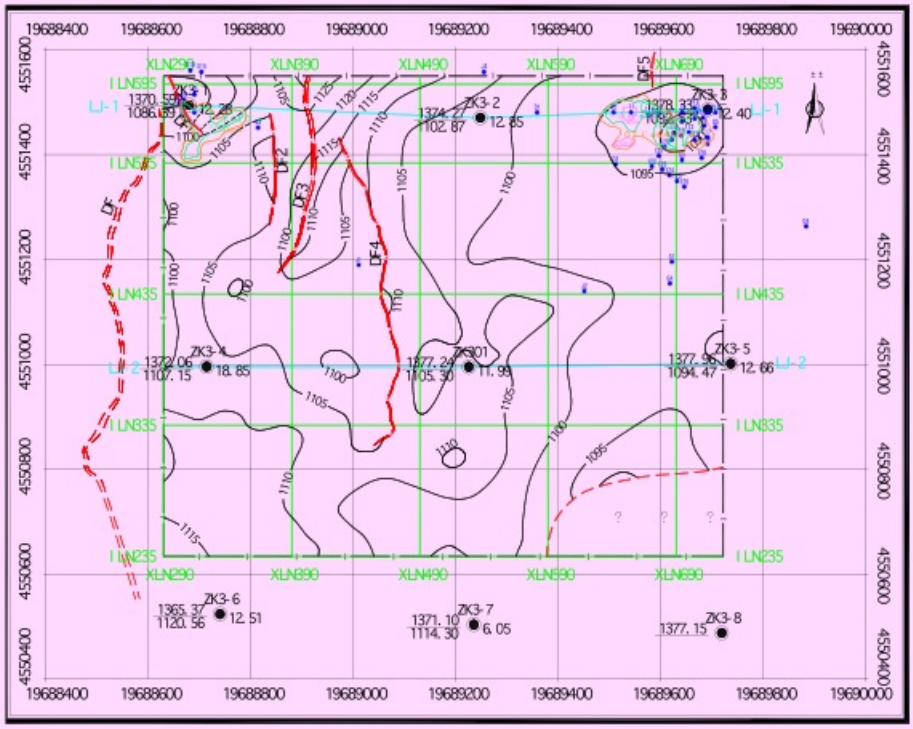


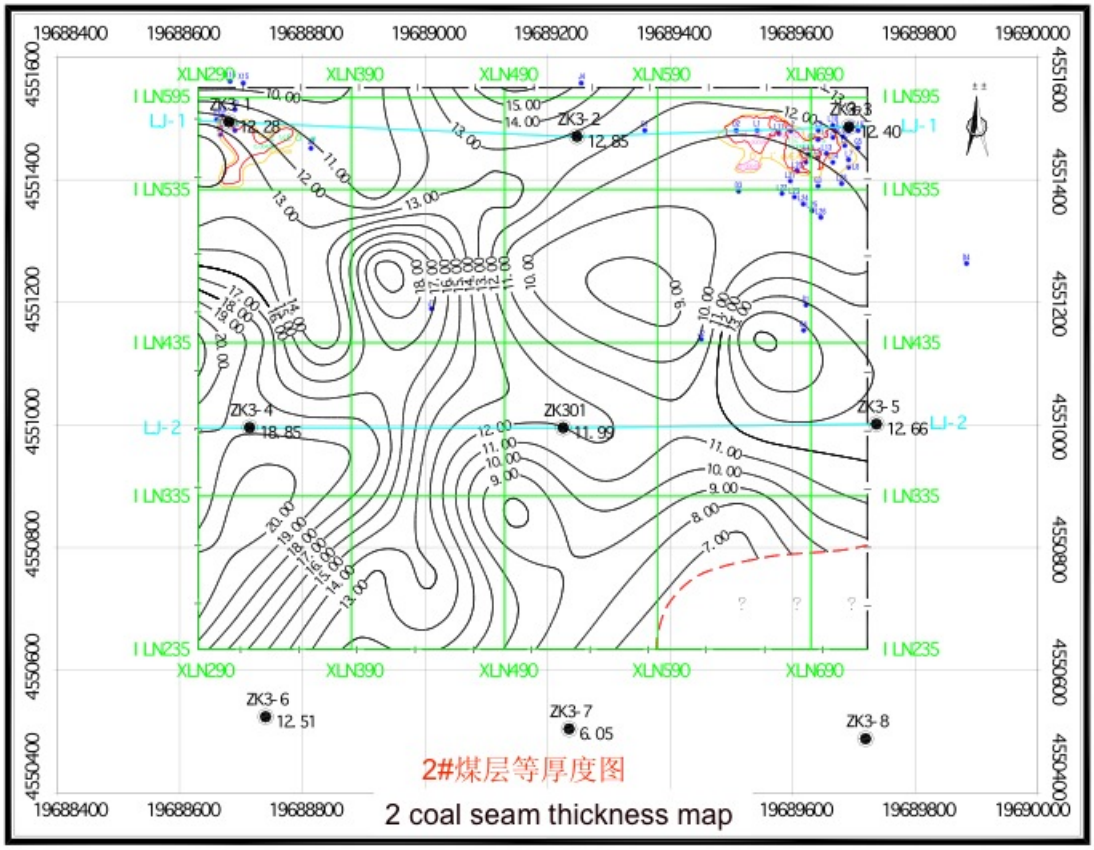
2 seam fracture distribution and connectivity of graph



Wallpapers 2 seam crack expansion trend analysis

2 coal combustion bottom contours and surface wipe out area layout

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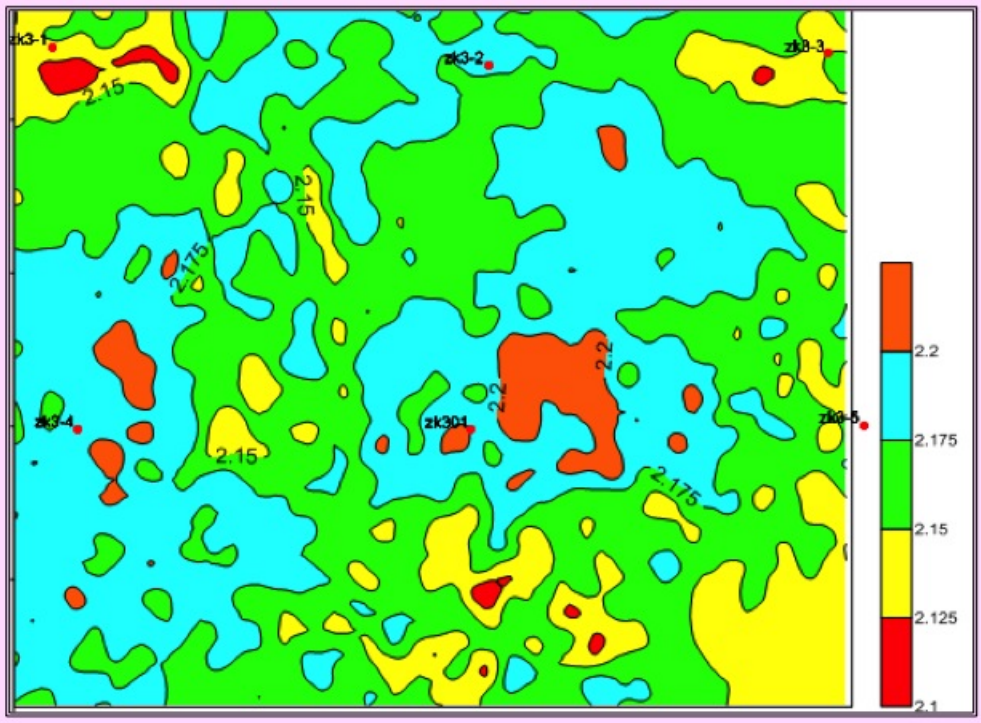
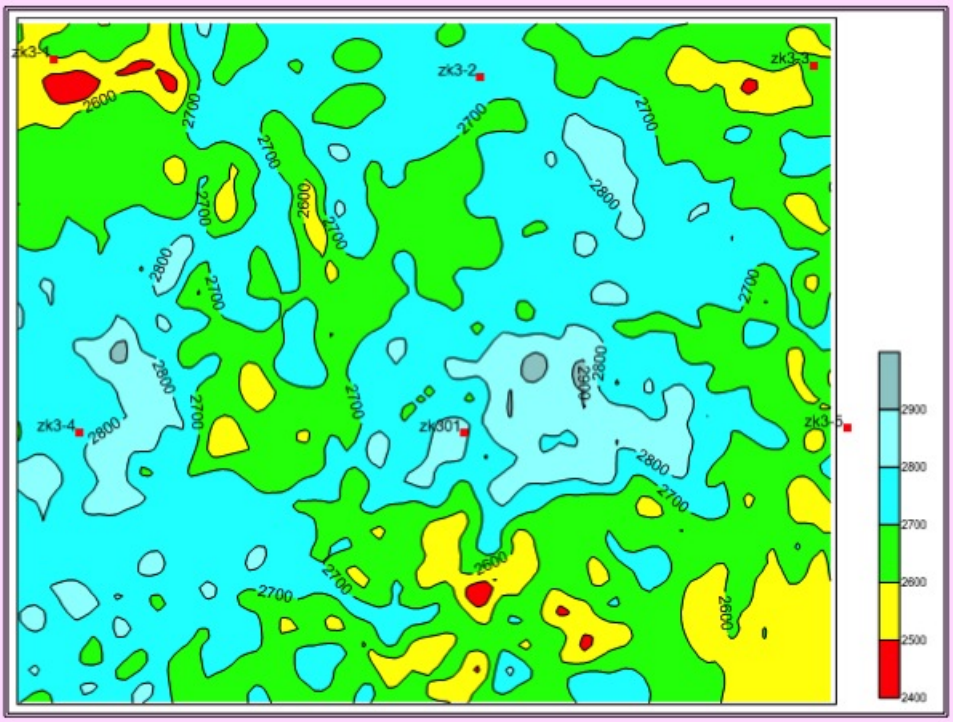
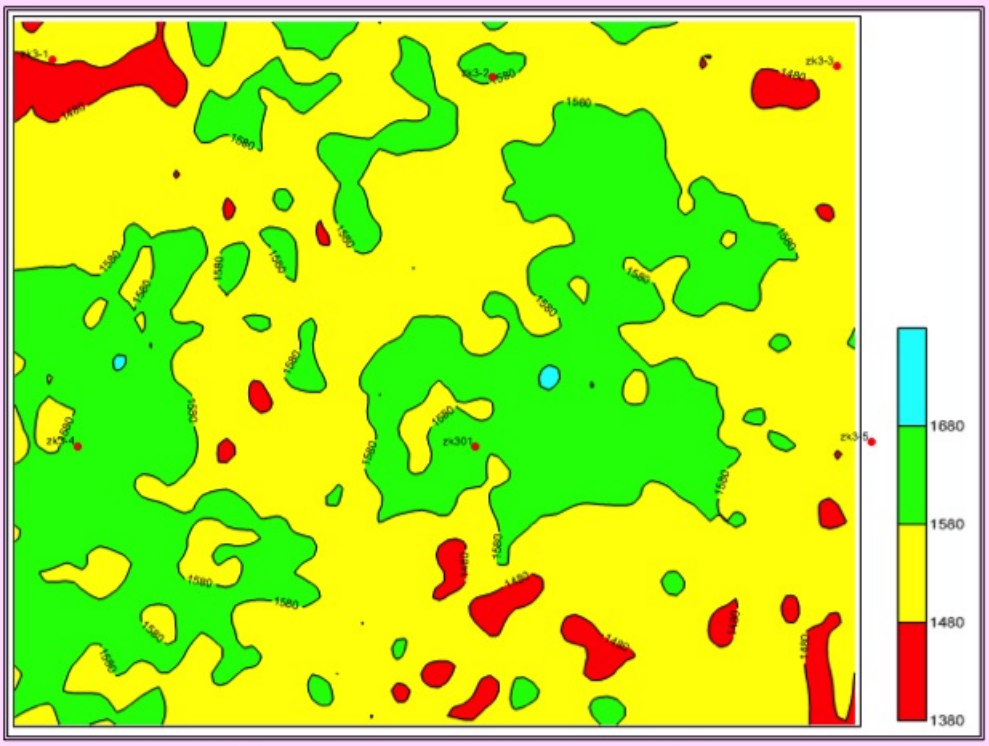
4550600
4550400
XLN290
XLN390
XLN490
XLN590
XLN690
I LN595
I LN535
I LN435
I LN335
I LN235
LJ-1
LJ-2
ZK3-1
12.28
ZK3-2
12.85
ZK3-3
12.40
ZK3-4
18.85
ZK301
11.99
ZK3-5
12.66
ZK3-6
12.51
ZK3-7
6.05
ZK3-8
2#煤层等厚度图
2 coal seam thickness map



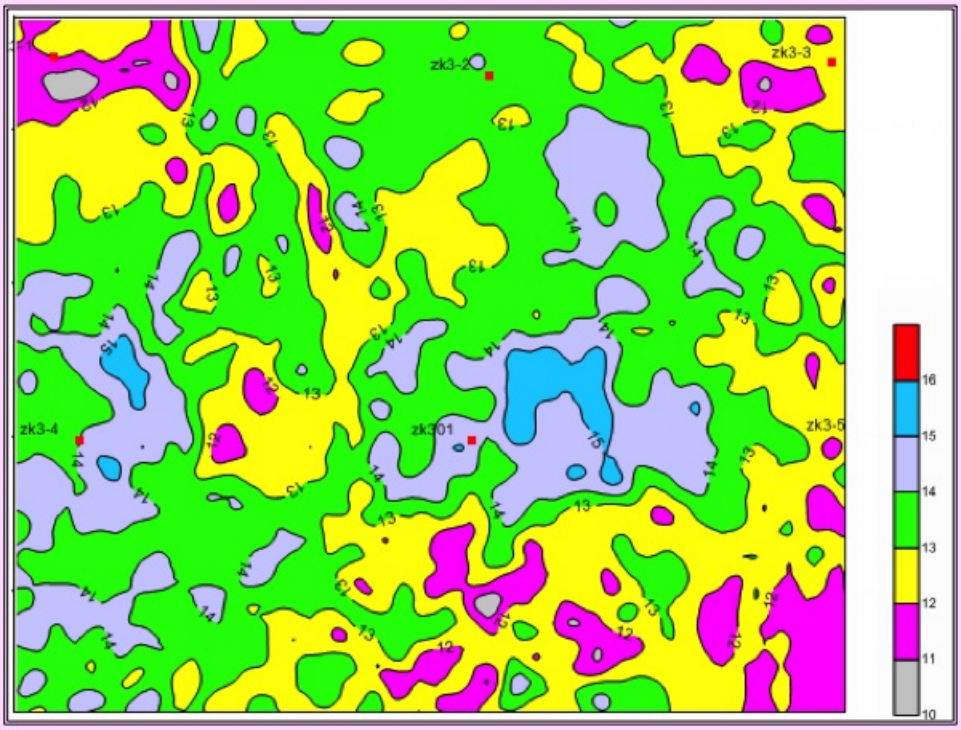
2 roof rock density maps （g/cm^3）



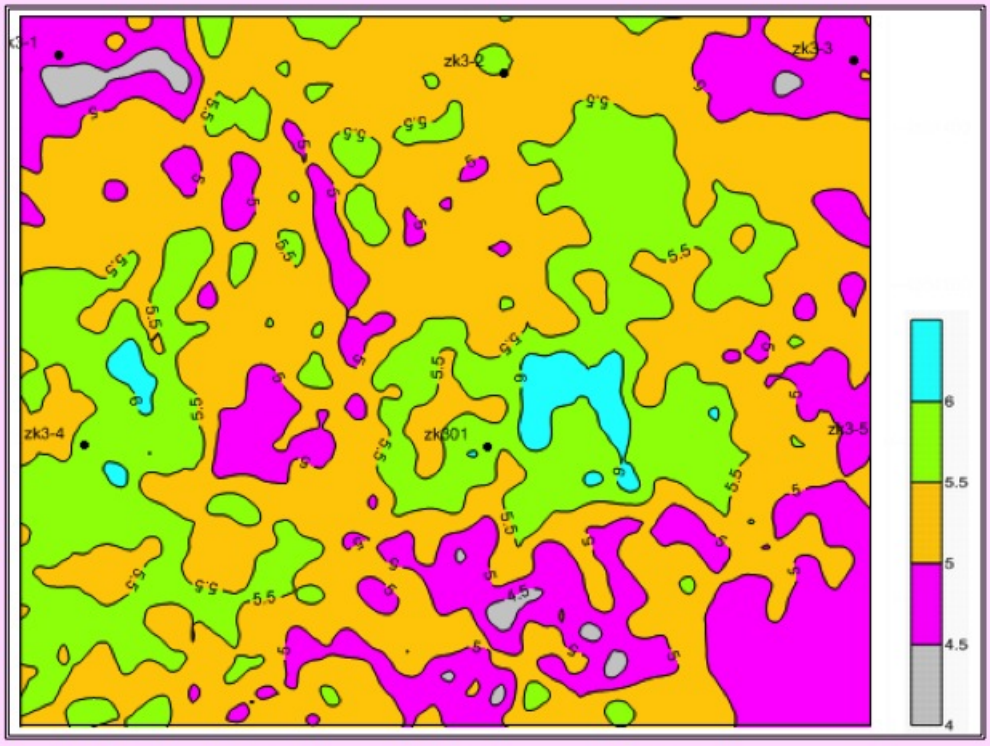
2 roof rock wave velocity map （m/s）



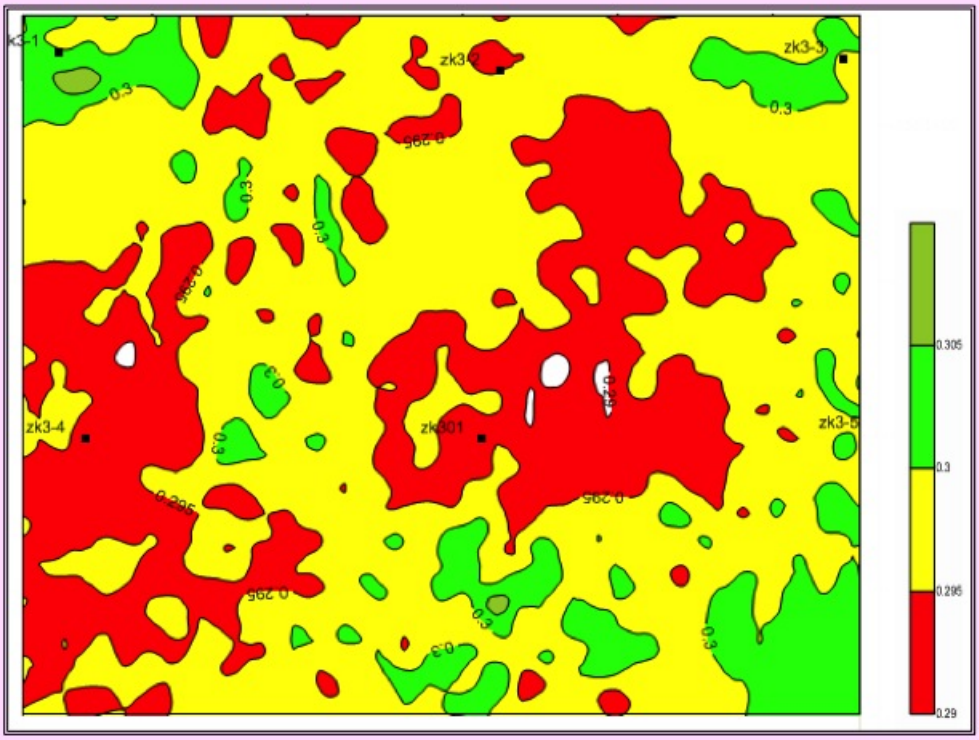
2 roof rock wave velocity map （m/s）



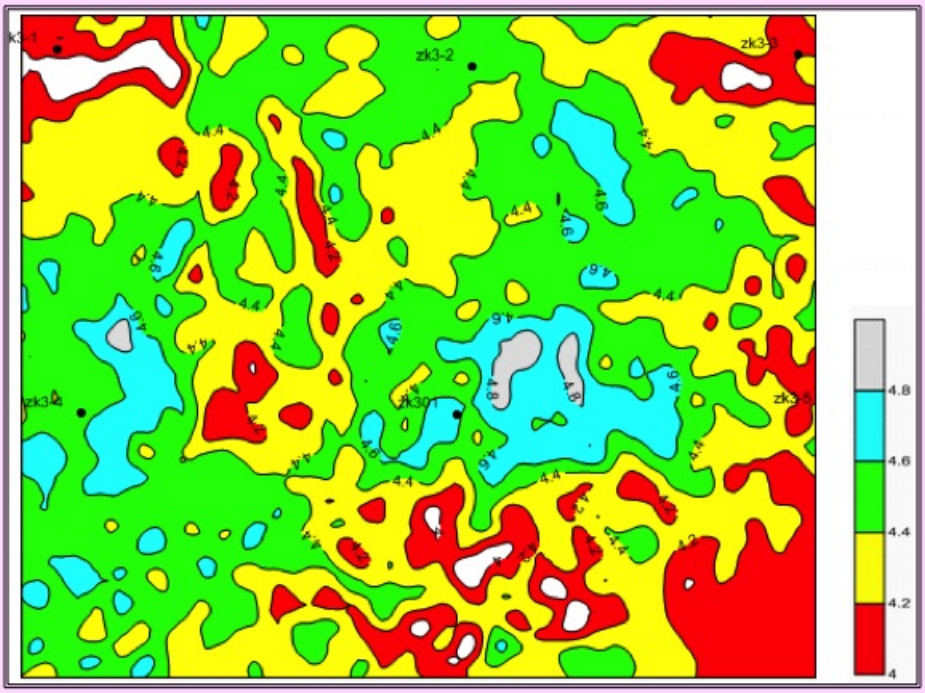
2 roof rock mass elastic modulus map （GPa）



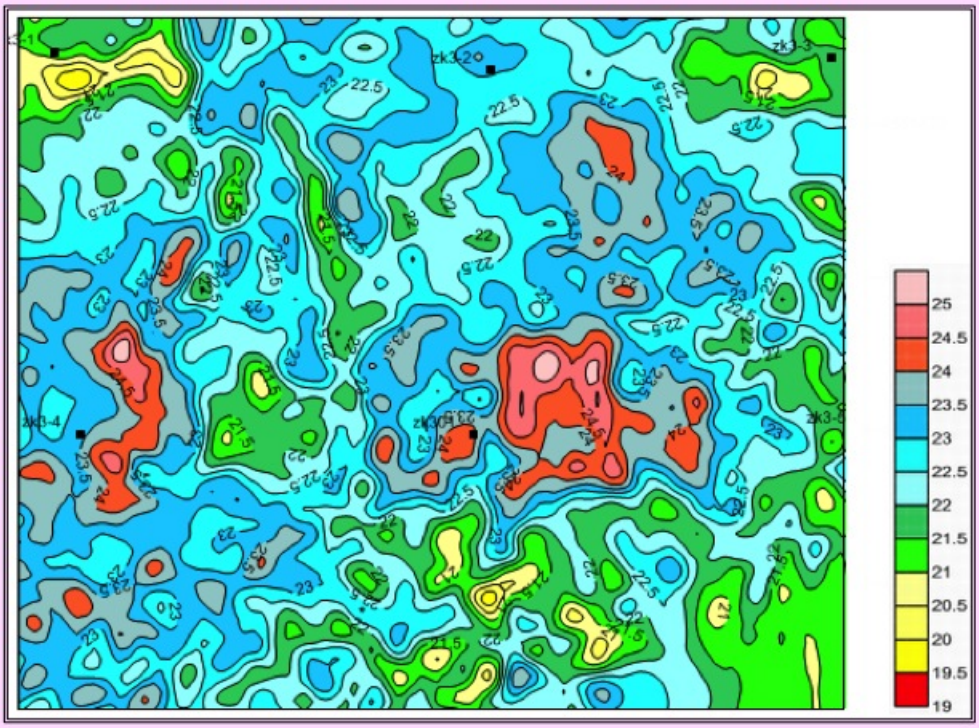
2 roof rock shear modulus map （GPa）



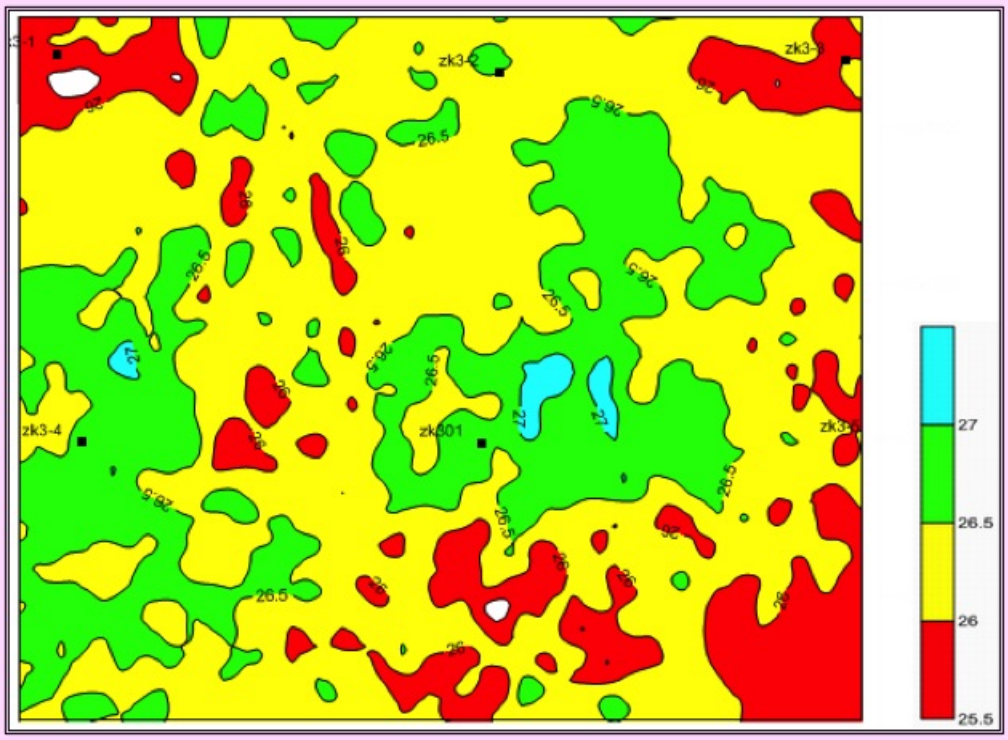
2 roof rock Poisson's ratio chart



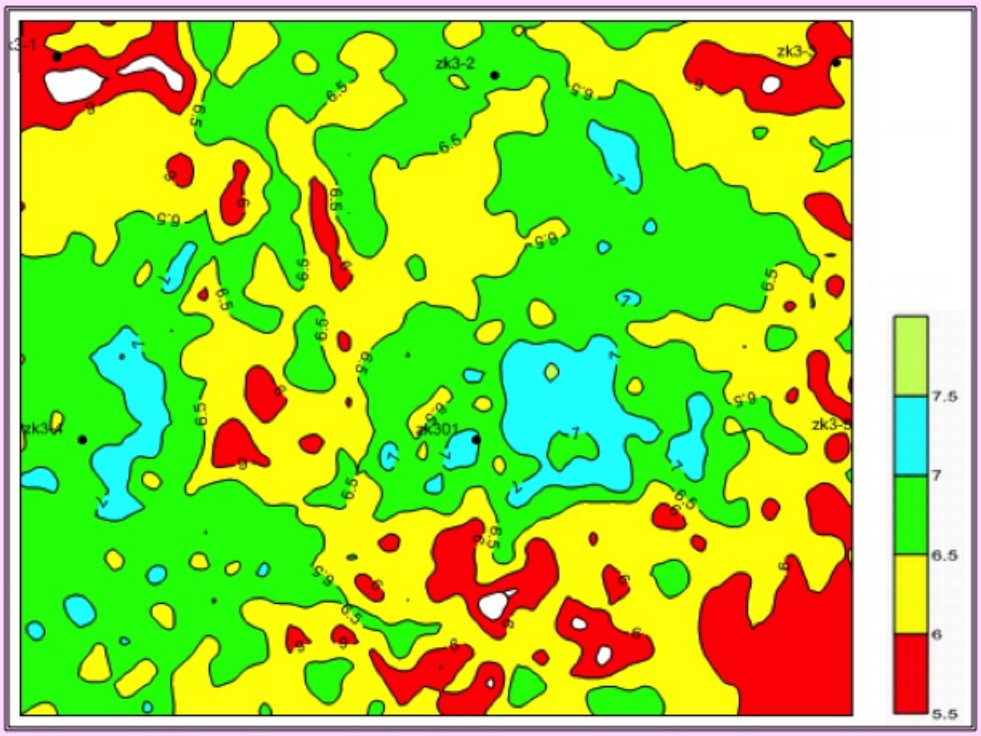
2 In situ tensile strength of roof rock map （MPa）



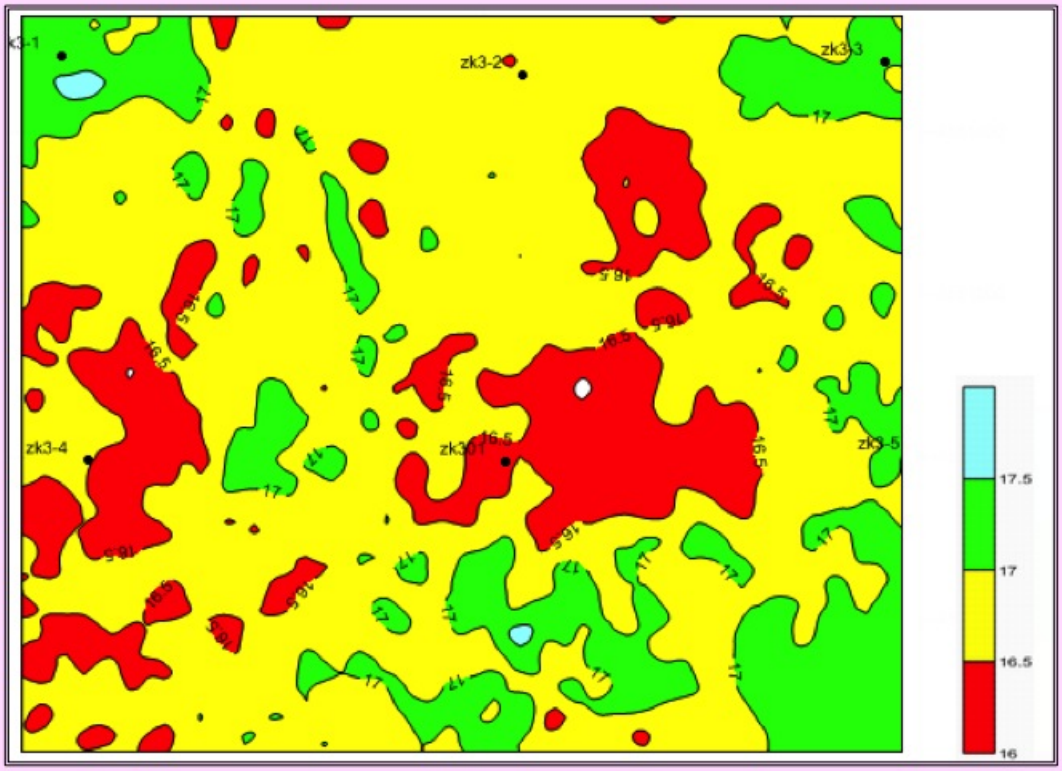
2-situ compressive strength of roof rock map （MPa）



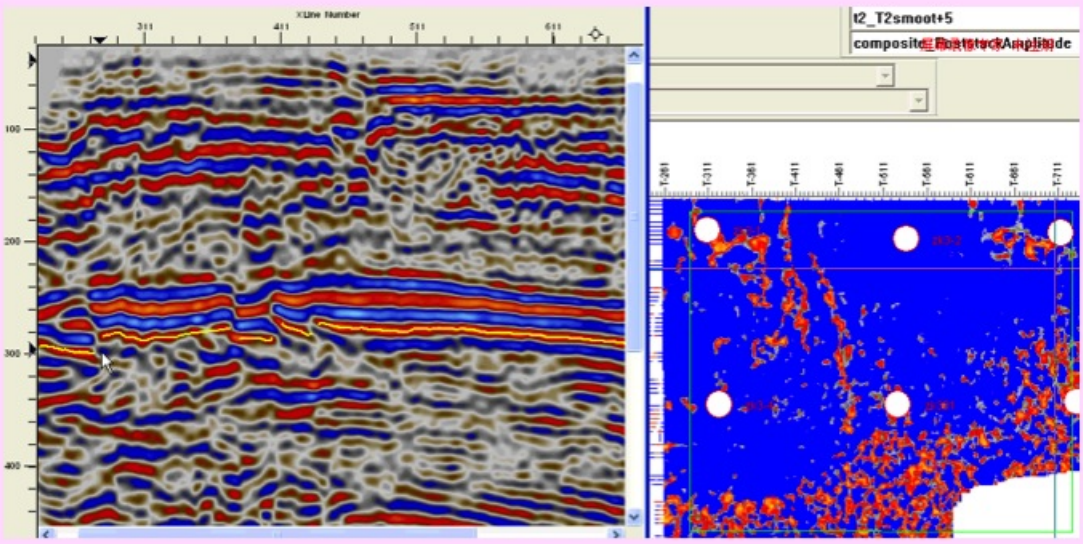
2 seam friction angle of roof body diagram



2 roof rock mass cohesion （MPa）



2 roof rock porosity map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