

TECHNICAL NOTE

Ref. No.: GK/BYL-2005-0173
Project: Byley Gas Storage Project
Job: Subsurface Engineering - Stage 1
Date: 26 July 2005

Subject: XRD and thin sections results on drakelow 2A

Due to the uncertainties identified in the mineralogical content of the Northwich Formation, an investigation (considered as minimum by GK) consisting in XR diffraction and thin sections on a few selected core samples (salt and shale/marl) from well Drakelow 2A was performed in Ecole des Mines de Paris (see report).

The XRD results are as follow (Italic text Quoted from the "Ecole des Mines" Report):

"BULK ROCK

Bulk rock analysis has been conducted on a non oriented powder. The estimated error is approximately $\pm 5\%$.

| Sample depth (m) | Clay | Quartz | Dolomite | Halite | anhydrite | Magnesite | other |
|-------------------------|-------------|---------------|-----------------|---------------|------------------|------------------|---------------------------------|
| SALT | | | | | | | |
| 527.65 | X | | | 100 | | | |
| 572.70 | | | | 95 | 5 | | |
| 572.9 | ? | X | | 90 | 10 | | |
| 635.65 | 10 | 10 | X | 70 | 10 | X | |
| 635.35 | 10 | 5 | X | 80 | 5 | X | |
| 652.10 | | | | 90 | 10 | | |
| SHALES | | | | | | | |
| 515.55 | 40 | 30 | 10 | 5 | 15 | | <i>FeldK, plagio, haematite</i> |
| 516.67 | 40 | 40 | 5 | X | 15 | | <i>FeldK, plagio, haematite</i> |
| 560.25 | 25 | 35 | 20 | 5 | 15 | | <i>FeldK</i> |
| 661.76 | 15 | 10 | X | 70 | 5 | | |
| 672.62 | 35 | 30 | 20 | 10 | 5 | | <i>haematite</i> |

Legend:

Mineral proportions are indicated in percentage, total 100,

X - mineral present, proportion below 5%,

other - mineral present, proportion below 1%

CLAY MINERALS

The analysis is conducted on the < 2 μm fraction. Four sets of diffraction patterns were used: air-dried, glycolated, hydrazine-saturated, and one heated at 500°C for 3h.

A semi quantitative composition of the main mineral phase was estimated by the comparison of the curve described by all peaks of a mineral phase and empirically obtained curves for different amounts of this mineral. The estimation of the clay mineral content in the < 2 μm fraction was determined by comparison of the main peak surfaces of the glycolated XRD diagram.

The estimated error for bulk clay mineralogy is $\pm 5\%$.

| Sample depth (m) | Illite | Chlorite | Chl/Sm |
|------------------|--------|----------|--------|
| 515.55 | 3 | 3 | 4 |
| 516.67 | 3 | 3 | 4 |
| 560.25 | 5.5 | 4.5 | |
| 661.76 | 5.5 | 4.5 | |
| 672.62 | 6 | 4 | |

Legend:
clay mineral assemblage, total 10

Samples 515.55 and 516.67, contain a large proportion of interstratified chlorite/smectite. These interstratified clay minerals are quite regular and can be considered as very close to the corrensite clay mineral".

GEOSTOCK EVALUATION - CONCLUSIONS

From the analysis, it is clear that the unexpected log response which triggered the requirement for mineralogical analyses is explained by the quite high quartz content of the claystones/shales which can reach 40% of the total. To be accurate, the claystones should be more properly termed locally "siltstones" (rather than "marls"!). The thin section at 661.76 m confirms the ubiquity of quartz in these series.

This result reinforces the ELAN logging interpretation.

Also surprising is the relatively high quartz content associated with the mixed halite facies (see samples 635.65 m and 661.76 m).

When halite is very pure, only anhydrite is present which is in accordance with the depositional sequence (see samples at 572.7 m and 652.1 m).

One sample (527.65 m) has a 100% halite content. It corresponds to the "pure strong red salt" well identified on cores as probably re-mobilised salt filling free spaces (the thin section at 661.76 m suggests also a complex crystallisation of the salt). In the cored section 505.6-707 m, this "veined" salt has a total "thickness" of 3.7 m. The thickest "interval" is between 527.51 m and 529 m. It is most probable that wireline logs cannot discriminate this specific facies.

The main clay minerals present in the Northwich Formation are illite and chlorite with proportions varying respectively from 55/45 to 60/40.

Dolomite and anhydrite are present in more or less equivalent proportions in the claystones.

An interesting result was obtained from the samples collected at 515.55 m and 516.67 m in the most fractured interval of the well (two ICEL wells experienced recently an air kick when drilling into a marl band located at an equivalent position in the salt sequence).

The main minerals are clay (note 5% halite at 515.55 m). In addition to illite and chlorite, the analysis shows an interstratified clay chlorite/smectite which can be considered as corrensite.

This very specific mineral could be a sedimentary and/or a diagenetic marker of this particular interval.

This could assist to understand the lack of integrity of the interval and deserves a more thorough investigation based on fresh core samples.