PALADIN ENERGY LTD
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12 May 2016

Memo

To: **File**

From: **James Thom**

aiSIRIS results from Angela Terraspec work

Summary and Conclusions

Angela

- The SWIR band is dominated by montmorillonite which is consistent with previously acquired XRD
- Only extremes in carbonate concentration register small SWIR spectral contribution
- An attempt at grouping clay mineral combinations failed to yield anything meaningful
- Samples that had 'white mica' and not chlorite or kaolinite as part of the spectral are generally nearer surface and their presence is likely to be related to surface weathering processes
- Dominant VNIR mineralogy and the associated redox interpretation differs from the visually logged redox interpretation and may be a better and more consistent way to collect redox interpretation information

Introduction

VNIR and SWIR Spectra of 740 laboratory pulps from Angela were acquired using a Terra Spec 4 HiRes were sent to consultants AusSpec International for processing.

The spectra were processed using the AusSpec's (proprietary?) software aiSIRIS.

Following is a discussion of the aiSIRIS outputs and AusSpec's interpretation.

Definitions

VNIR (very near infrared) 400 – 1400nm

SWIR (short wave infrared) 1400 – 2500nm

Angela

Original Questions

The work conducted by Ausspec International on Paladin's Manyingee samples that determined the % of total clay each clay phase contributed would be an interesting exercise to carry out to see which clay species dominate others to aid ore type investigations. Perhaps the same can be done with these samples?

Montmorillonite dominates the VNIR spectral signature of pretty much all the samples. This is consistent with vermiculite and smectite (montmorillonite) reported as the dominant clay mineral from the XRD analysis conducted in 2015 (Figure 3).

Other clay minerals that contribute to the spectra are kaolinite, white mica and chlorite. White mica is the next most spectrally dominant mineral followed by kaolinite and chlorite. The data in the spreadsheet had a field that combined each of the minerals identified in the spectra.

An exercise was conducted where the SWIR mineral assemblage combinations reported for each spectra were simplified and analysed to see if any trends emerged.

Combining knowledge about the gangue mineralogy gained from the XRD analysis and lessons learnt from geological logging it was assumed that montmorillonite and carbonate are ubiquitous at Angela. Therefore every group defined in a clay mineral combination modelling exercise would contain a background (and variable) concentration of both these minerals.

The hyperspectral analysis showed a difference in the spectral contribution of kaolinite, chlorite and white mica. Therefore it was hypothesised that using these three identified clay minerals there may be up to 8 clay mineral combinations as defined by SWIR clay mineralogy (Figure 1).

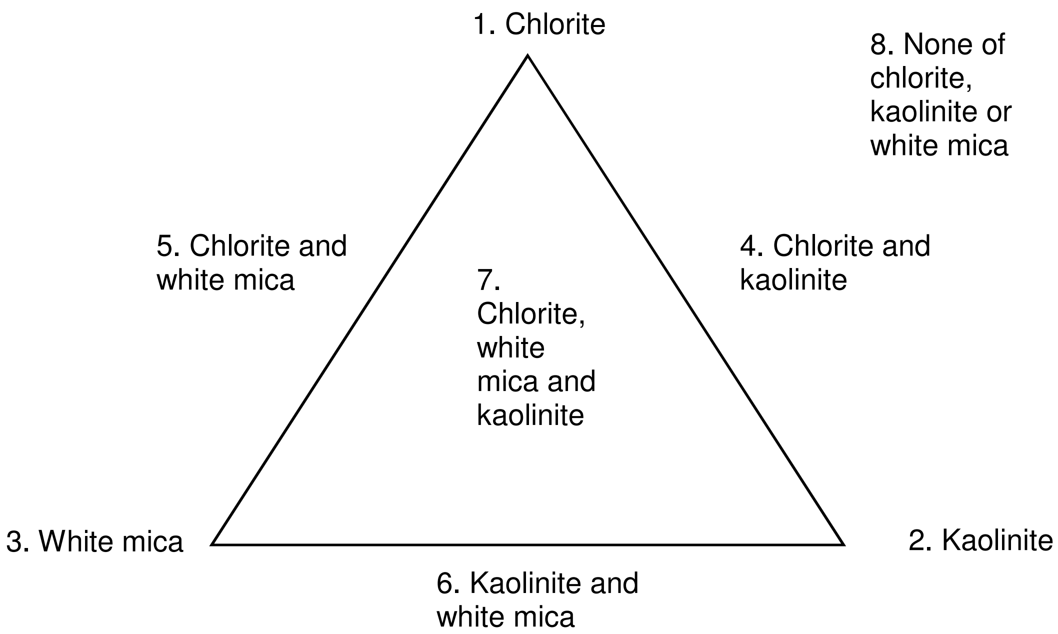

Figure 1: Potential clay mineral combinations

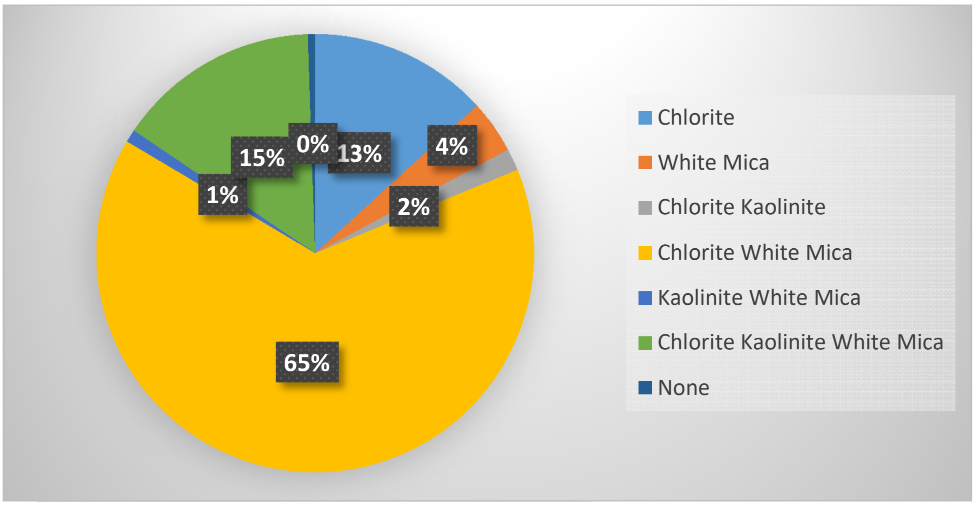

Figure 2: Proportion of samples that report to each potential SWIR clay mineral combination

Figure 2 shows that, of the 8 hypothesised groups, there are three main groups which, at this stage means nothing.

Backtracking… does the spectral contribution mean anything in regard to actual variation in concentration of SWIR mineral? This was checked using the SWIR results of the samples for which XRD analysis was also acquired.

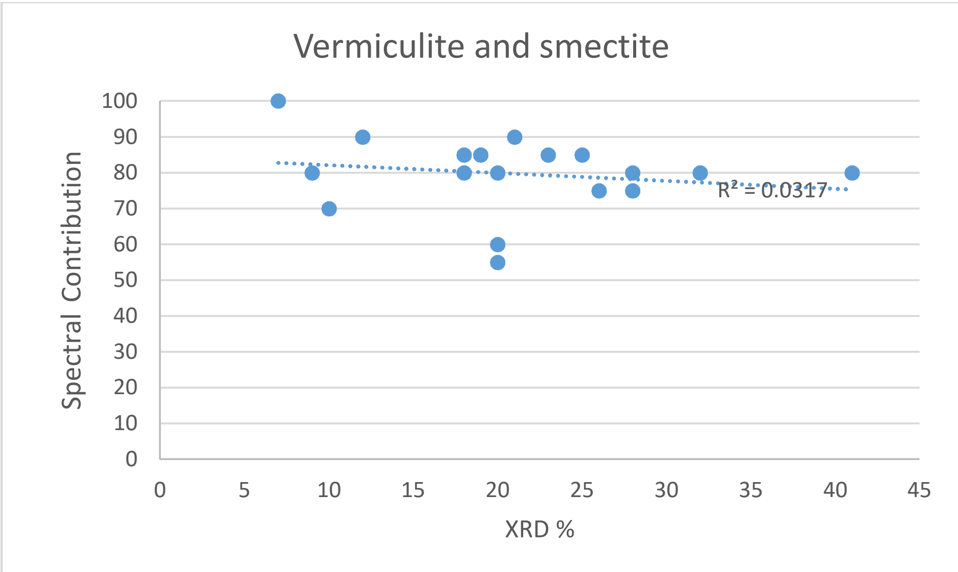

Figure 3: the data point of ~10% montmorillonite as reported by XRD is coincident with a 100% spectral contribution even though nearly all other samples have a greater XRD % montmorillonite

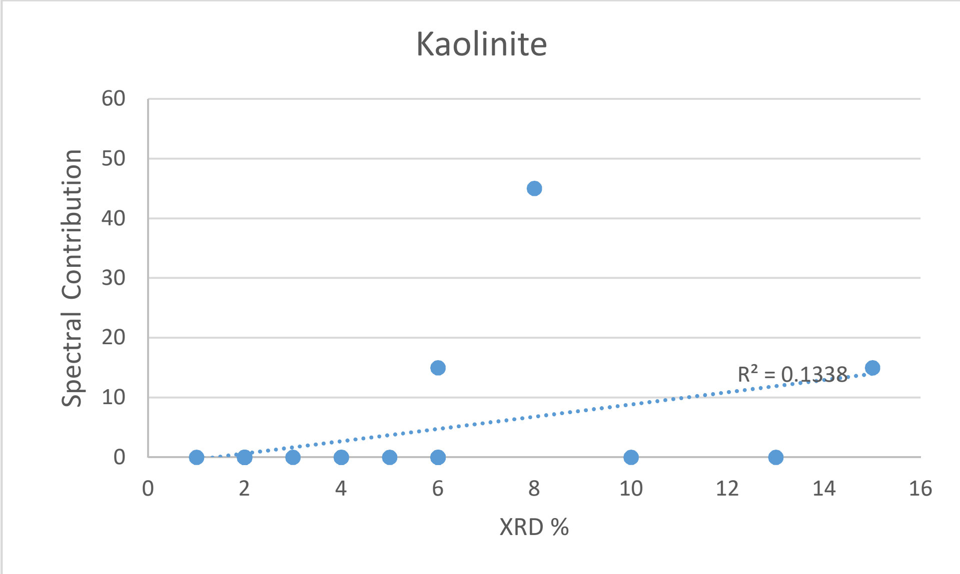

Figure 4: for a range of kaolinite concentrations no spectral contribution was recognised

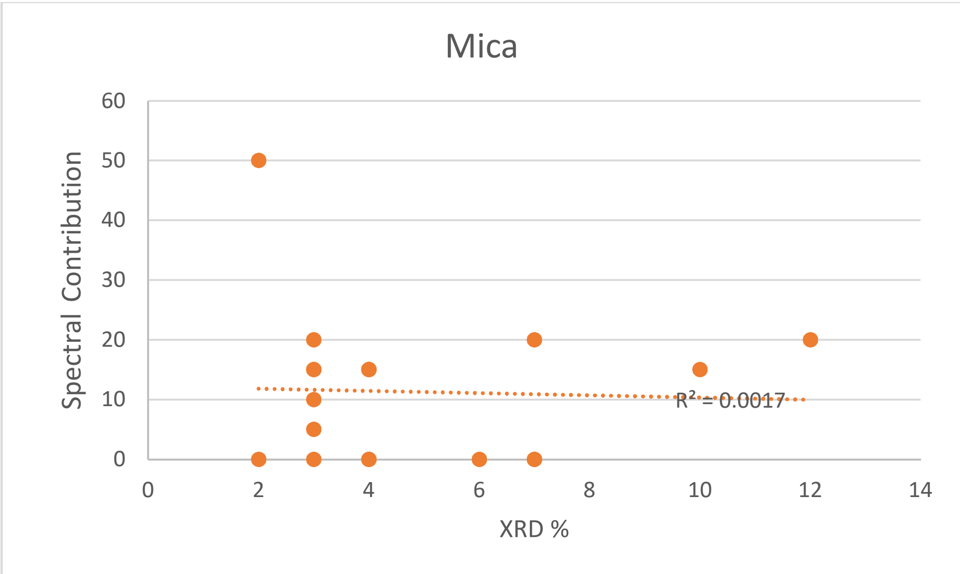

Figure 5: As for kaolinite

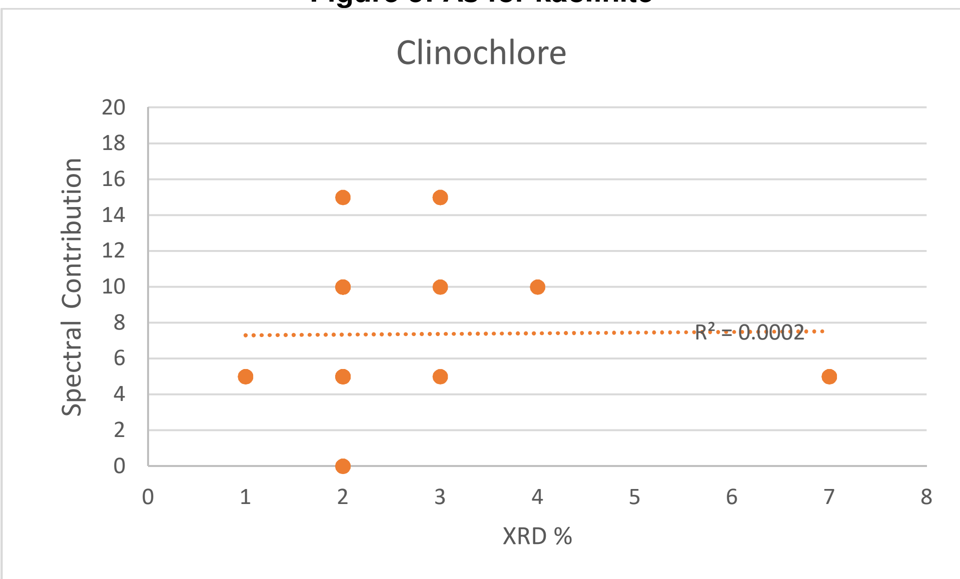

Figure 6: As for kaolinite

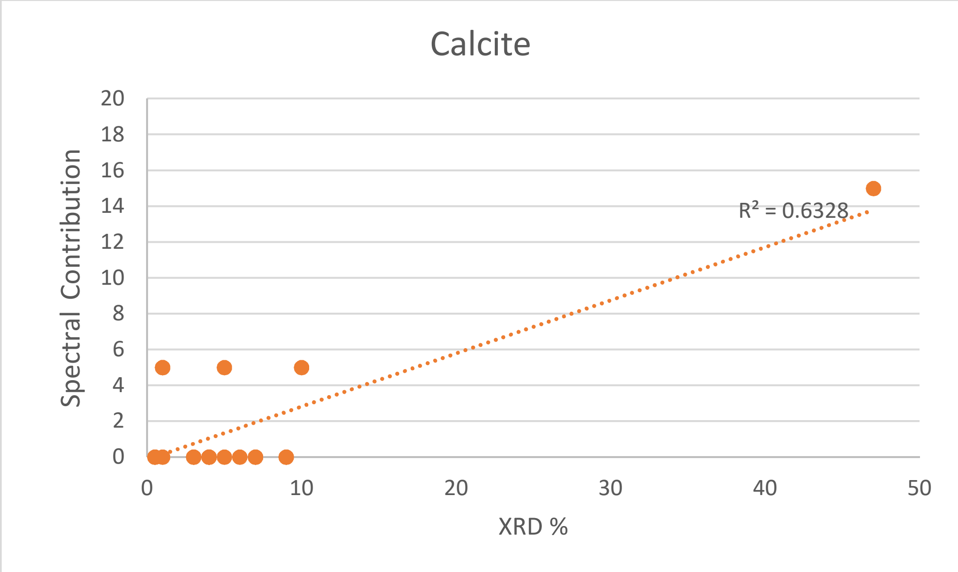

Figure 7: Only the sample with a significant percentage of calcite was determined to have a spectral contribution between 15% carbonate which suggests that the only very high carbonate concentrations will be distinguishable from lower concentrations.

From the shown XY plots and their R^2 values it is concluded that the spectral contribution is not a strong quantitative indication of the relative concentration of each mineral identified in the SWIR analysis and as such may not be a very good way to identify clay mineral combinations.

Carbonate was also identified in some samples, but as Figure 7 shows, the magnitude of the spectral contribution poorly relates to the determined mineral percentage determined by XRD. It can also be seen that for a range of XRD determined concentrations no spectral contribution was recognised.

What was noticed in the SWIR mineral assemblages was the spatial location of the clay mineral combination defined as ore type 3 ‘White mica’. All the results cluster towards the near surface and as such are interpreted to be a weathering related feature. (Figure 8)

Figure 8: Reflectance vs the Z coordinate of samples, the green samples have a

spectral contribution from white mica without chlorite or kaolinite.

For the mineralized samples, will the absorption features shown to be associated with synthesized uranium minerals that were discussed by Bill Andrews be recognizable? (a PhD student from RMIT who analysed a significant amount of drill core at Paladin's Valhalla project)?

The three features for which there is a field in the aiSIRIS output (U1140, U1500 and U1550 were extracted by Ausspec based on experience at other uranium prospects. The mineral to which this uranium feature belongs is not defined. (Confirmed in a telephone conversation with Ausspec on 11th May 2016.

<u>Other investigations</u>

Feedback from Ausspec suggested that the VNIR mineral assemblage could be used to better define the oxidation state of each of the samples.

Nominated VNIR mineral assemblages were returned as one of those listed in Table 1:

Table 1: VNIR Mineral Assemblages returned in the aiSIRIS output

VNIR Mineral Assemblage	Use	What it means in relation to visual logging
Hematite	Self explanatory	OX
Fe oxide	Used when it is unclear if it is goethite or hematite	OX
Transition fe2_fe3	Self explanatory	TR
Chlorite	Self explanatory	RD
Goethite	Self explanatory	OX

The assigned redox state from visual logging vs the assigned redox state from VNIR mineral assemblage determination is tabled below.

Table 2: Comparison of the visually assigned redox interpretation and the VNIR redox interpretation

	OX	TR	RD
Visually logged (number of samples and % of population)	357	183	200
	48%	25%	27%
Determined by VNIR (number of samples and % of population)	227	106	407
	31%	14%	55%

The numbers in the table show that the VNIR mineralogy defines the interpreted redox state differently to visual logging.

The VNIR mineralogy may be more accurate and therefore helpful for geological modelling if Terra Spec analysis was collected on a routine basis. A true test of whether this would be the case would be to plot the VNIR mineralogy against a 3D model of the mineralization and the visually logged oxidation state.