Review of the UNCONGEO report

A guide for the assessment of thermogenic hydrocarbon occurrence.

Building the Basin Scale Picture

The UNCONGEO report provides a petroleum systems model and related Common Risk Segment (CRS) maps risking the encounter of thermogenic hydrocarbons in the Swiss Molasse Basin. This was based on integrated disparate data sources, from wells, seismic, outcrop (largely outside the AOI) and literature, across a large area of land. These data were then used to construct 2D petroleum systems models along five basin-scale cross-sections, oriented NW-SE between the Jura Fold belt and the Alpine front. The models use the underlying data, even though the data point locations are not evenly situated across the basin, and the level of confidence varies greatly across the study area. The depth of knowledge also varies between the various petroleum systems. For example, the Jurassic aged Posidonia source rock is better understood in terms of facies, distribution and quality when compared to the deeper, and rarely penetrated rocks of the Permo-Carboniferous. The modelling of timing of charge is further complicated by the need to specify the amount of missing section at the numerous unconformities. Additional uncertainty is posed by km-scale faults - some parallel to the basin, some cutting across – which, individually, may have acted either as hydrocarbon migration barriers, or as flow conduits, throughout the geological history. The ambiguous role of these faults in the petroleum system cannot be fully addressed in 2D cross-sections. A 3D petroleum system model would be required to resolve these interactions more realistically. When all the individual uncertainties are taken together, it is obvious that a considerable degree of uncertainty will result on any output.

The Common Risk Segment (CRS) Approach

The Common Risk Segment (CRS) approach used, is the correct method to bring together the data despite the uncertainties. It should not be considered an objective, absolute output, but a subjective method of comparing the risk in differing areas within the analysed perimeter. However, it is extremely important to always consider how the risk element of the CRS is defined.

In using these CRS maps, three main factors need to be considered:

1. **Definition of Risk**
   The report is entitled "Evaluation of the risk for the geothermal exploration associated with the presence of hydrocarbons in the subsurface of the Swiss Plateau". It is clearly set out in the text that the hydrocarbons that are being considered are of **thermogenic** origin only. The consideration of reservoir and seal properties in the combined CRS maps, shows that the final risk maps relate to conventional hydrocarbons, present in a free phase, trapped in stratigraphic or structural accumulations in the subsurface.

   We then need to consider **what is not being addressed in the risk**; the following list is not exhaustive but summarises the main factors not being considered.

   - Microbial gas
   - Shale gas
   - Tight gas

- Basin centred gas
- Hydrocarbon gases dissolved in an aquifer

In summary, when two adjacent areas are being compared, and, for example, one is low risk for encountering hydrocarbons, while another is high, this only refers to the chance within that area polygon of encountering thermogenic hydrocarbons if a valid trap is encountered. Even in an area marked as high risk, a location in a syncline with no valid trap is unlikely to encounter hydrocarbons as defined in the risk template. Such a location could still encounter hydrocarbons of the types mentioned in the list above (e.g. shale gas), if the geological conditions would be favourable.

2. **Absolute versus Relative Risk**
A second major point concerns the quantification of risk. The report rightly avoids absolute risk vales and, instead, used words such as “High”, “Medium” or “Low” to distinguish the **relative risk** between different polygons. This avoids overconfidence but requires careful interpretation. There is a tendency to see high-risk areas as areas where the risk being evaluated is more likely than not. However, a good analogy showing the fallacy of this argument, would be to consider the likelihood of individuals being struck by lightning. Of course, there are areas where lightning strikes are more common than other areas, and could even be termed “high risk”. However, the absolute quantified risk is likely to be very small.

3. **Uncertainty in Location**
A function of the production of the combined CRS maps (CCRS) is that relatively high-risk areas occasionally juxtapose relatively low-risk areas. This suggests that the line separating the two polygons possesses a particular significance and is a **precise boundary**. In many cases this line represents the best estimate of a limit of sub-crop, or the presence of a feature such as a Permo-Carboniferous graben. Since the location and limits of these grabens are subject to considerable uncertainty, it would be wrong to put too much confidence on their absolute control of the CCRS maps.

Additionally, many of these polygons are determined by the presence or absence of source rock facies. **Lateral migration** from these kitchens will also add to the uncertainty, and hence, the true risk distribution is fuzzier than the maps suggest.

Conclusions and Implications

In summary, the UNCONGEO report provides an excellent **work flow** to construct petroleum system models and CRS maps. The analysis allows assessment of potential output scenarios taking into account the uncertainties in the available input data.

The presented CRS maps form a **first-pass screening tool** for the relative risking of encountering thermogenic hydrocarbons in traps, should a trap be encountered. For their practical application to the siting of geothermal wells, they should not serve as a decision-making tool for project planning or permitting purposes. It is strongly recommended that additional work is undertaken with new or own data, if possible, on a finer (target) scale. The risk of **microbial gas** and any other sort of **unconventional hydrocarbons** needs to be considered. Even in areas of relatively high risk, drilling in a proven syncline or monocline would change the risk profile.

To further minimise risk during assessment of a potential geothermal drill site, particular attention should be given to the **3D structural framework** at target scale; its potential to have supported a hydrocarbon accumulation by forming timely structural traps (or not), lateral reservoir compartments, fluid flow conduits or barriers or, instead, post-accumulation breaches, may point at both upsides and downsides. Finally, the areal uncertainty needs to be considered. Understanding the data or interpretation that determines **polygon boundaries** is crucial.