第十六届全国古地理学及
沉积学学术会议

Confidence Levels for the Textural Data Used in Reservoir Quality Assessment

Xintao Wang[1*], Barrie Wells[2], Ricki Walker[2]

[1]Department of Applied Geology, University of Goettingen, Goldschmidtstr.3, D-37077 Goettingen, Germany;

[2]Conwy Valley Systems Limited, West Acre, Conwy, LL31 9BN, UK;

**e-mail address: ds07069101@163.com;*

Mobile phone Nr.: +86 15165267951

August 22, 2021 Xi'an

Reservoir Quality Assessment is based on property data

- Simple physics and geometry together tell us that ***the amount of hydrocarbons in place*** is determined by ‘how much space’ and ‘what proportion of that space is hydrocarbon’.

- Hence ***rock properties*** are primary model parameters.

Measurement Uncertainty

This leaves the question: how much uncertainty is there in the input parameters?

We look here at the input from measurements of rock texture:

Grain size
Sorting (Grain size distribution)

To investigate the uncertainty, we first need to consider how the measurements are made.

How are Rock Property Measurements made?

Measurements of Grain Size and Sorting (and, more generally, of the Grain Size Distribution) can be divided into:

3D methods

and

2D methods

3D Methods: Examples:

- Sieving
- Liquid suspension sedimentation
- Centrifuging
- Laser granulometry

3D Methods: in general

Benefits: ability to measure grain size distributions based on the full 3D extent of the grains.

Along with method-specific drawbacks, all 3D methods suffer from some inherent ***limitations***.

3D methods: limitations

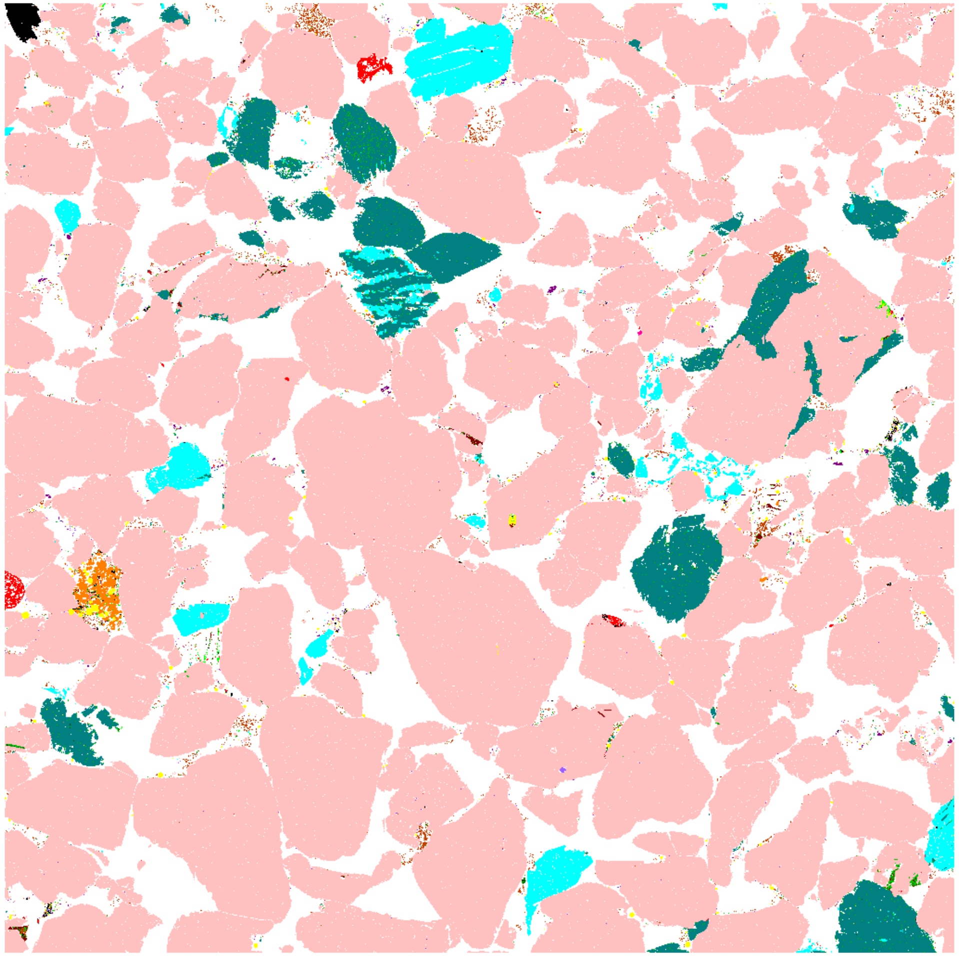
1) Disaggregation is required: even if this is possible, it can lead to errors;
2) They cannot distinguish original grain from overgrowth
3) They lose structural information;
4) Information on bulk mineralogy is lost.

2D Methods: Examples

- Image Analysis
- Optical Microscopy

2D Methods: Examples

- Image Analysis (e.g. Qemscan)



Benefits:

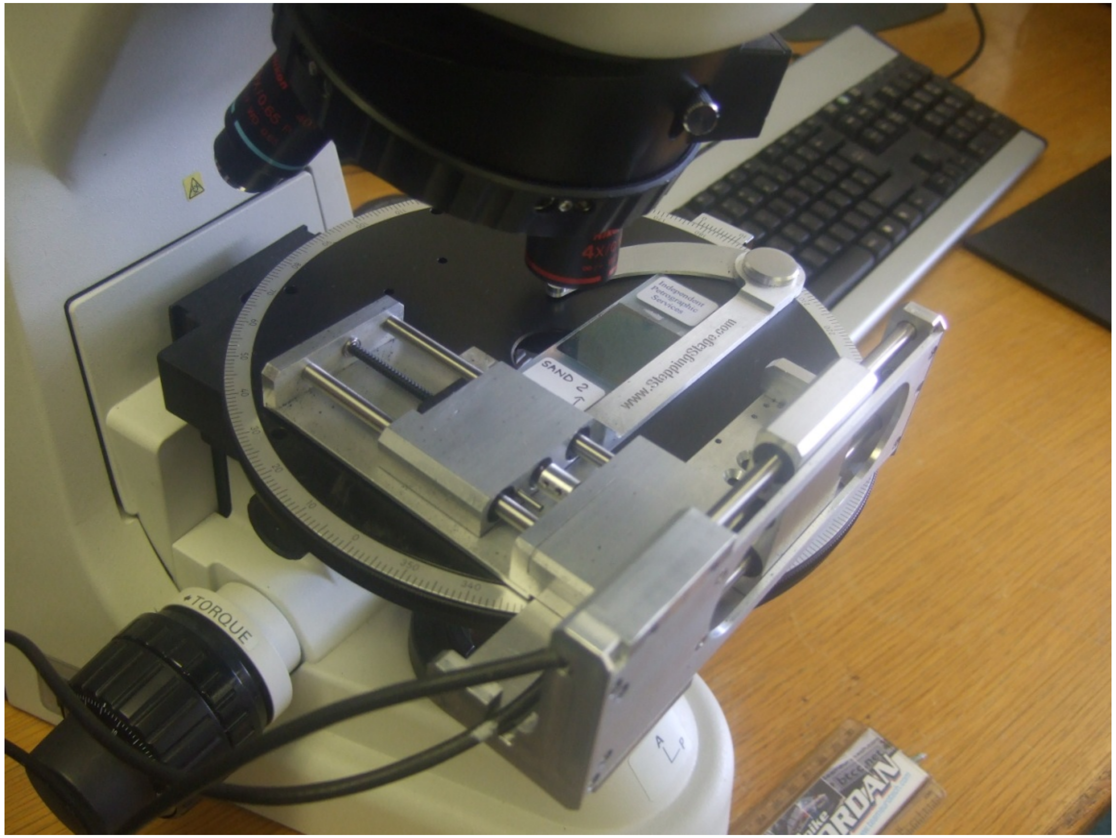
- Fast;
- Objective (not subjective);
- Measures all grains, so no need for cut-offs or targets.

Drawbacks:

- Based on chemistry, it does not distinguish grain from overgrowth / cement;
- Requires expensive equipment.

2D Methods: Examples

➢ Optical Microscopy: petrographic point-counting



Benefits:

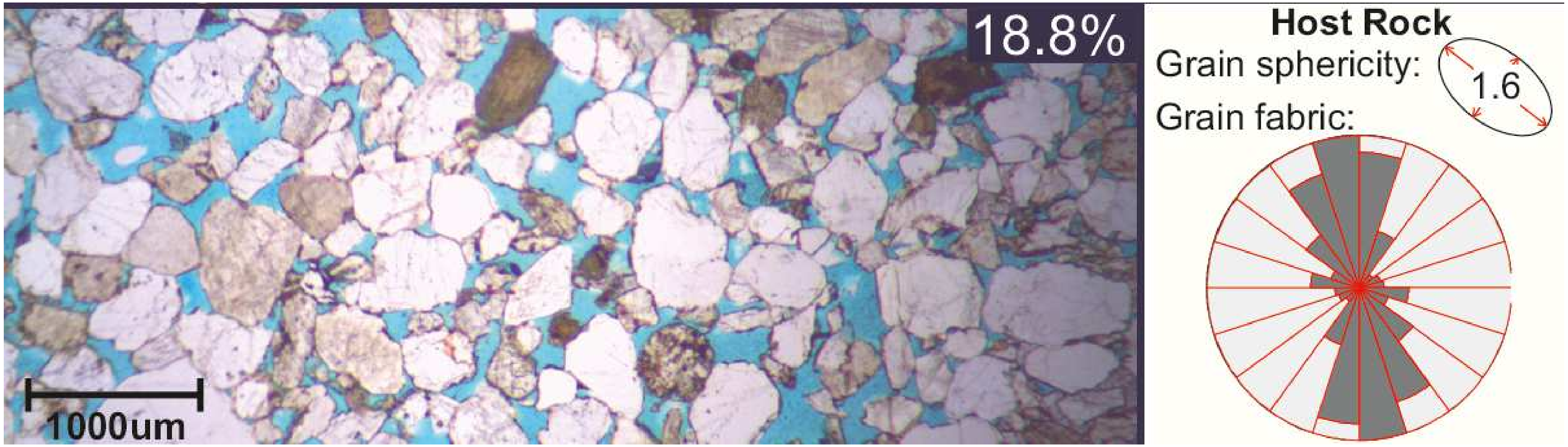
➢ Differentiation of original grains from fragments or authigenic materials;

➢ Textural, fabric and compositional data may be collected at the same time;

➢ comparatively cheap

2D Methods: Examples

➢Optical Microscopy: petrographic point-counting

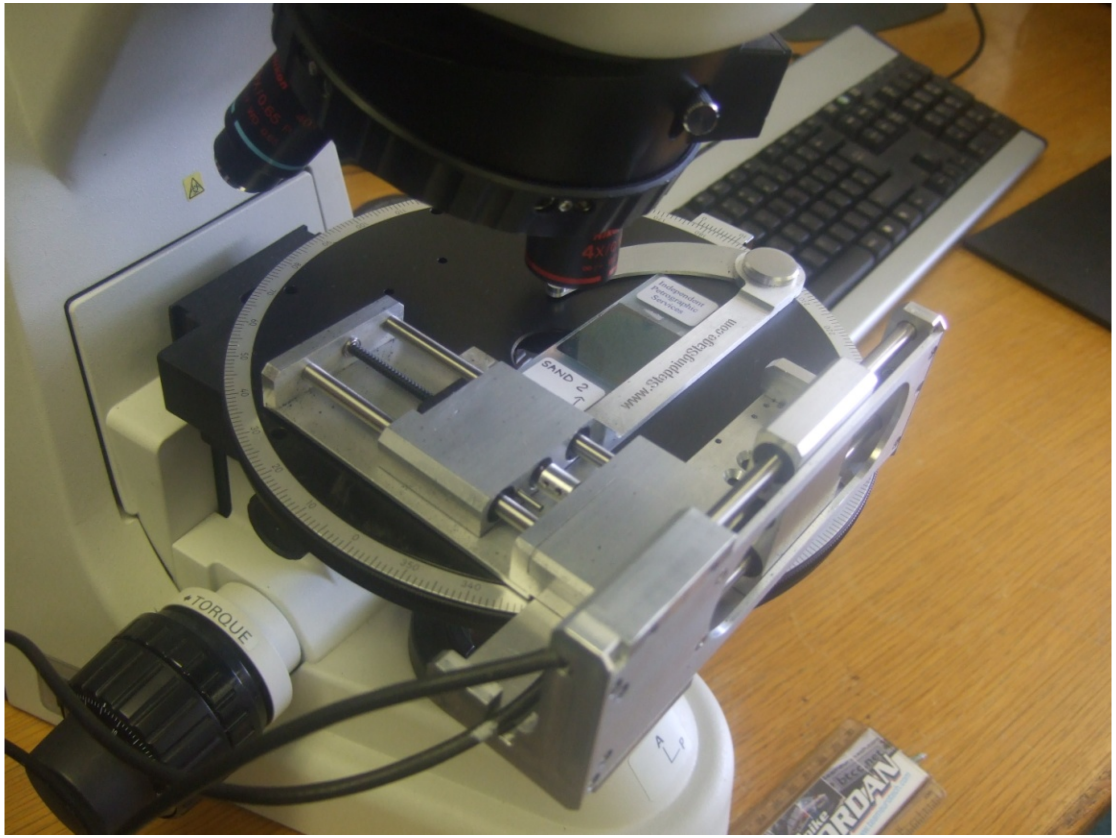


Benefits (continued):

➢Orientation data is unavailable from methods based on disaggregation.

2D Methods: Examples

➢ Optical Microscopy: petrographic point-counting



Benefits:

➢ Differentiation of original grains from fragments or authigenic materials;

➢ Textural, fabric and compositional data may be collected at the same time.

Drawbacks:

➢ Highly skilled task;

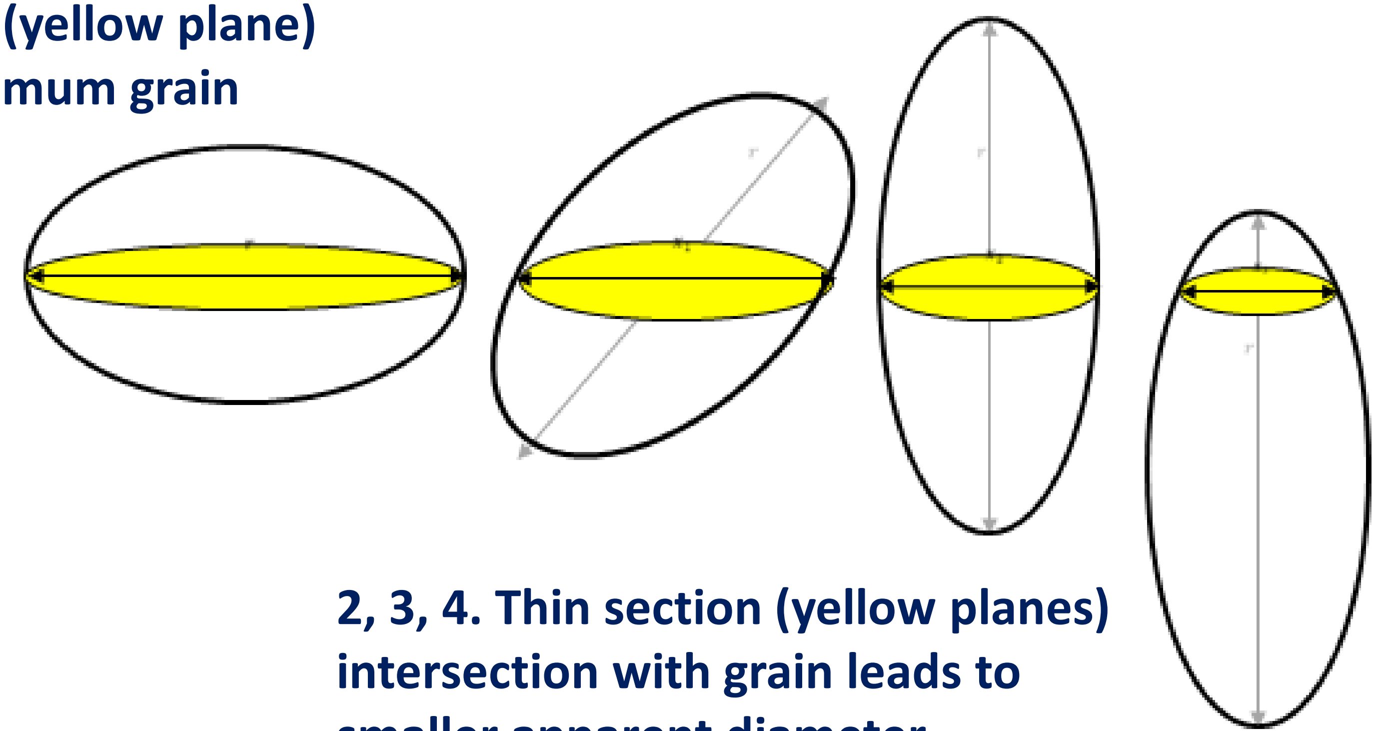
➢ Time consuming to do properly.

2D methods: limitations

As with 3D methods, there are some inherent ***limitations***.

The grain size apparent in thin section will be less than the true grain size:

1. Thin section (yellow plane) intersects maximum grain diameter.



2, 3, 4. Thin section (yellow planes) intersection with grain leads to smaller apparent diameter.

2D: Mitigation of Problems

We know that the 2D measurement will always be smaller than the true value, so we can mitigate.

Much work has been done based on spherical or other regular or idealised grains. This leads to **empirical correction factors.**

Uncertainty in Thin Section Point Counting

Uncertainty in data depends on the method by which it was collected.

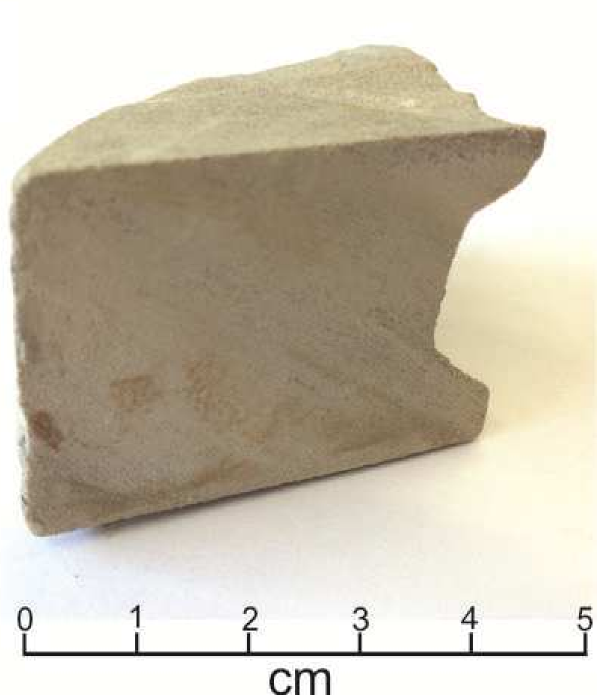
The most commonly used method for textural data collection is thin section point counting.

So we will be looking at 2D measurements taken on thin sections from core plugs, collected and analysed with the help of point-counting technology (PETROG)

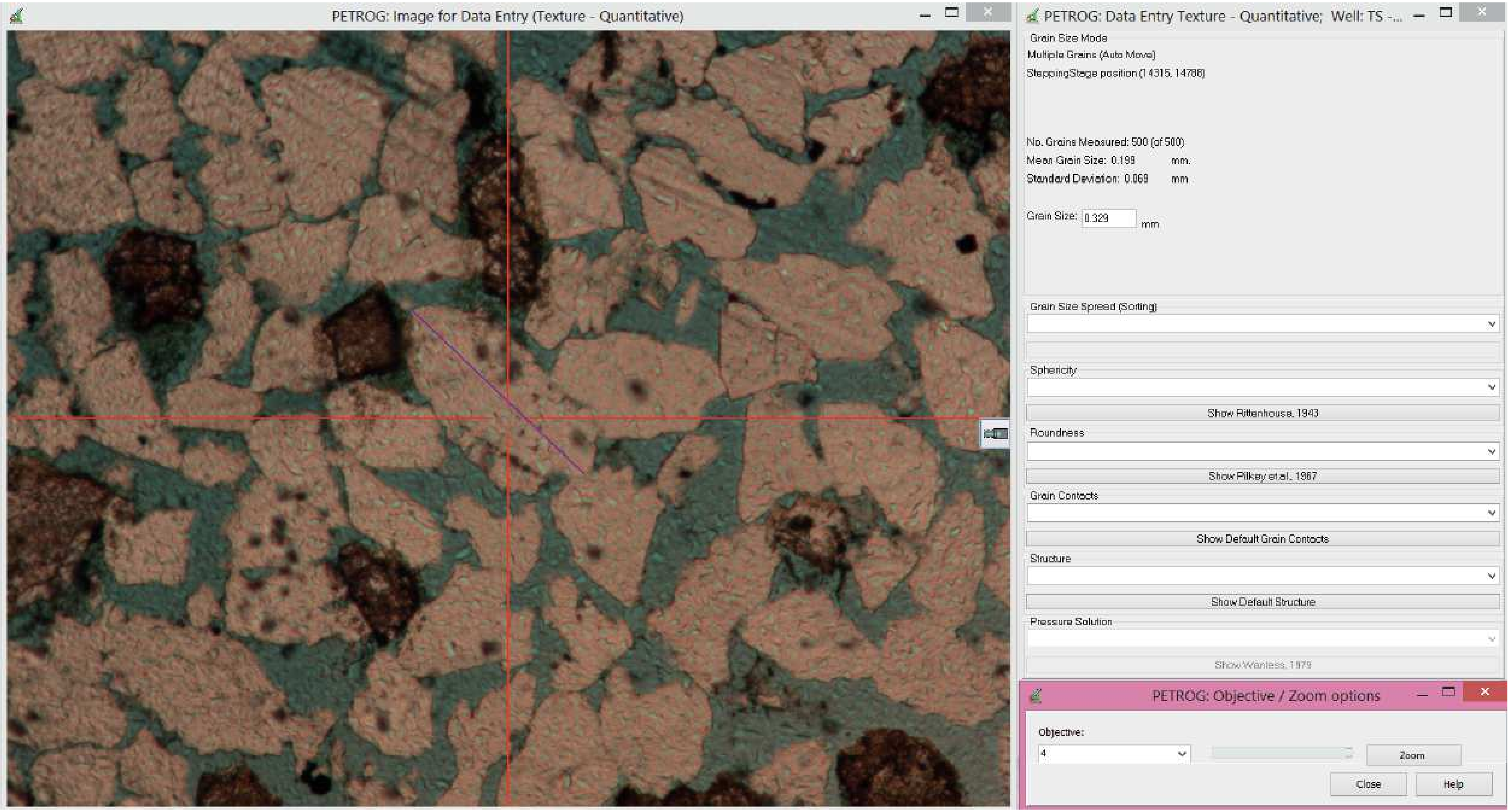
Stepping stage **Petrog software**

Example from North Sea, Brent formation sandstone

We further know that the data collected will depend on the rock type under examination. Here we look at North Sea Brent formation sandstone, the primary reservoir rock for some of the most prolific North Sea fields.

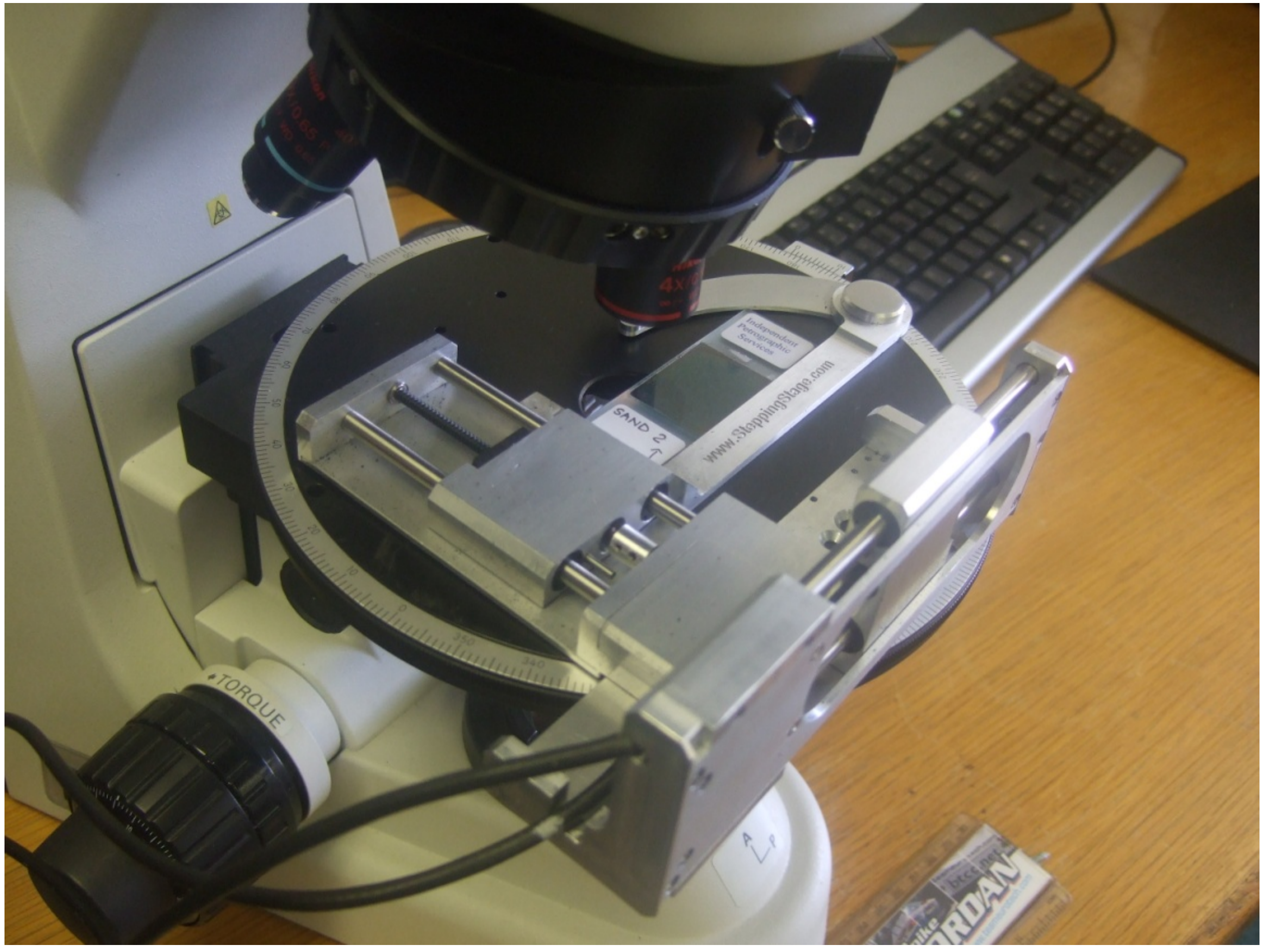


Measuring Grain Size in Thin Section



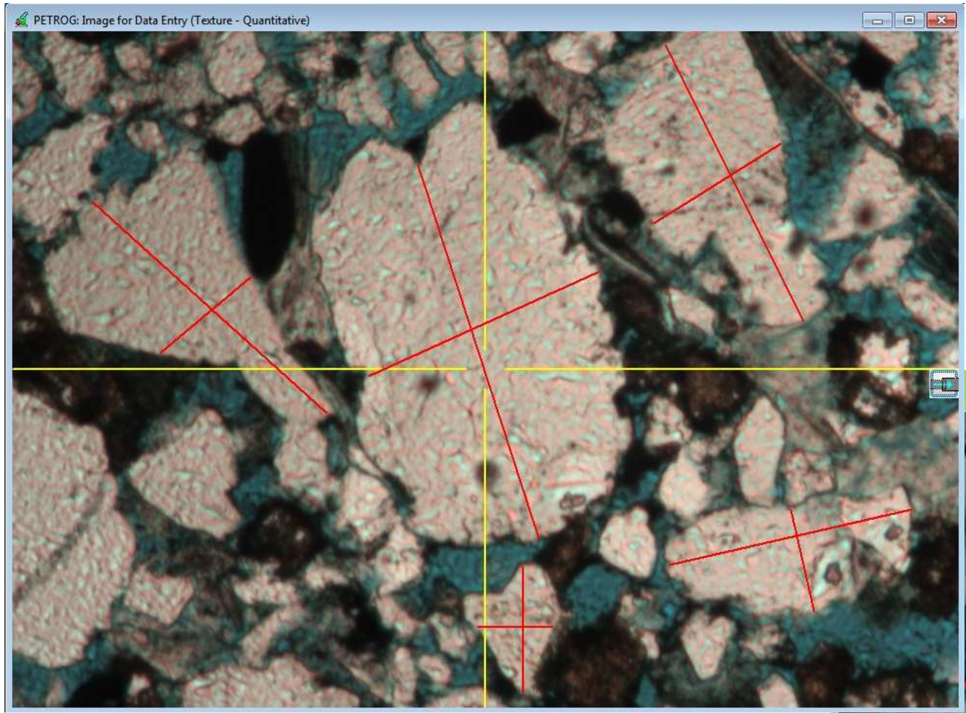
Point counting is a statistical technique, requiring many measurements to be made and then averaged. To assist, a stepping stage is invaluable.

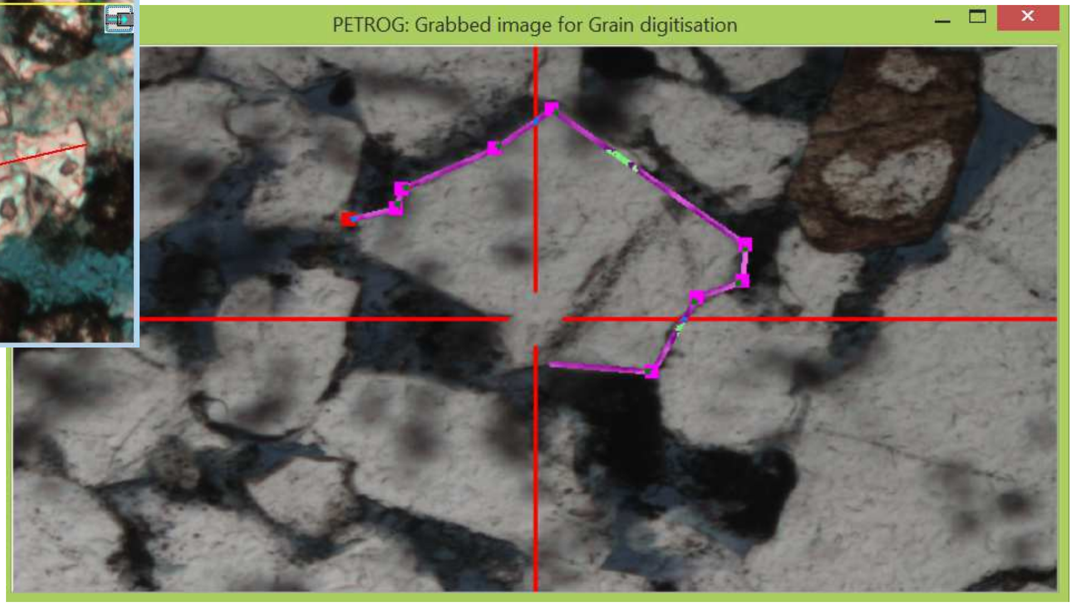
Thin Section Point Counting
Stepping Stage



A fully automated stepping stage will move to the next point to be measured immediately on completion of each measurement.

Measuring Grain Size in Thin Section





At each point, the grain may be measured either by clicking on 4 points (the ends of the major and minor axes) or by digitising the perimeter. Software assistance here is invaluable (*images from PETROG*).

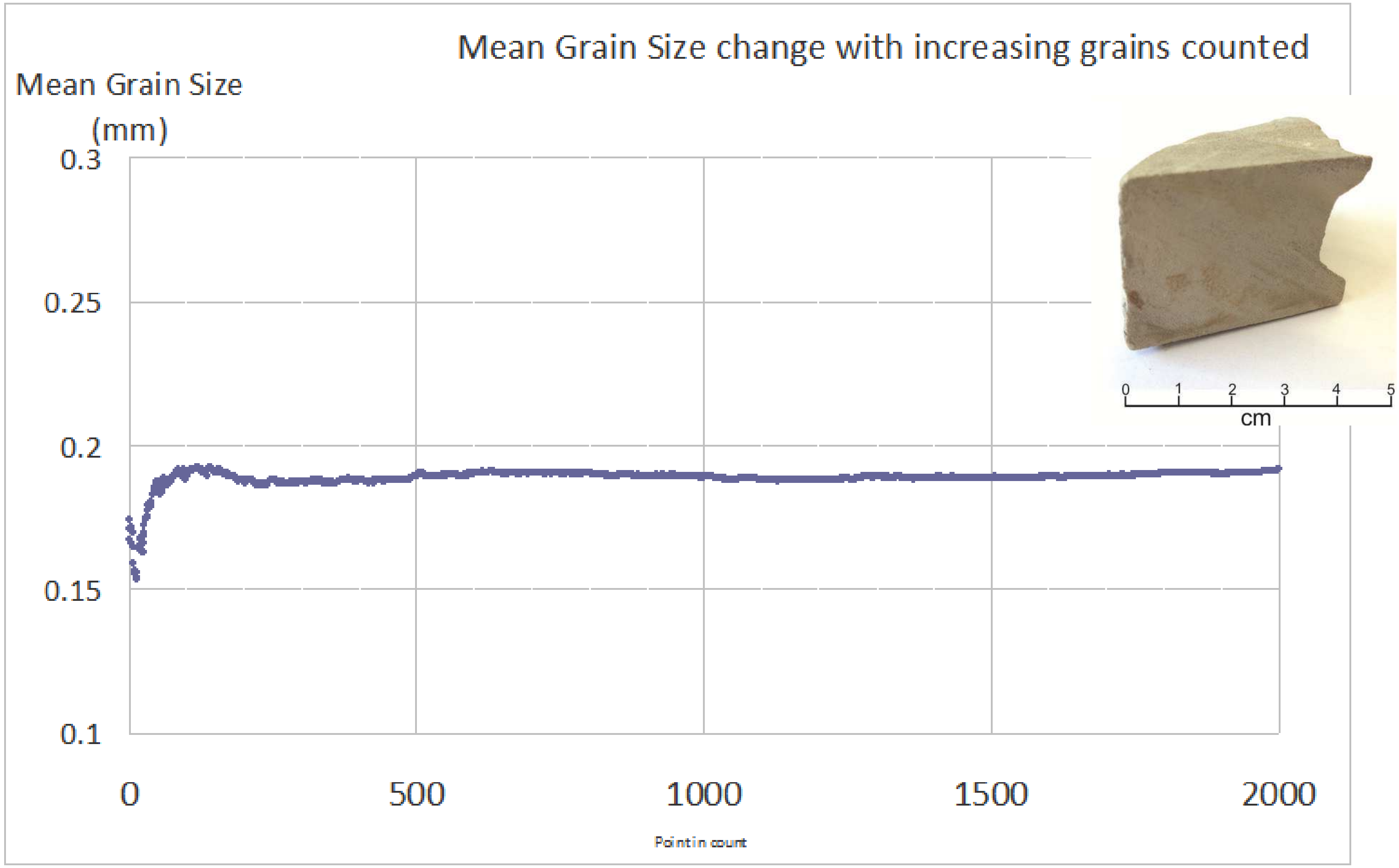
Uncertainty in Thin Section
Point Counting

But how many points (grains) should be measured? If we only measure one grain, is it likely to be representative of the whole sample?

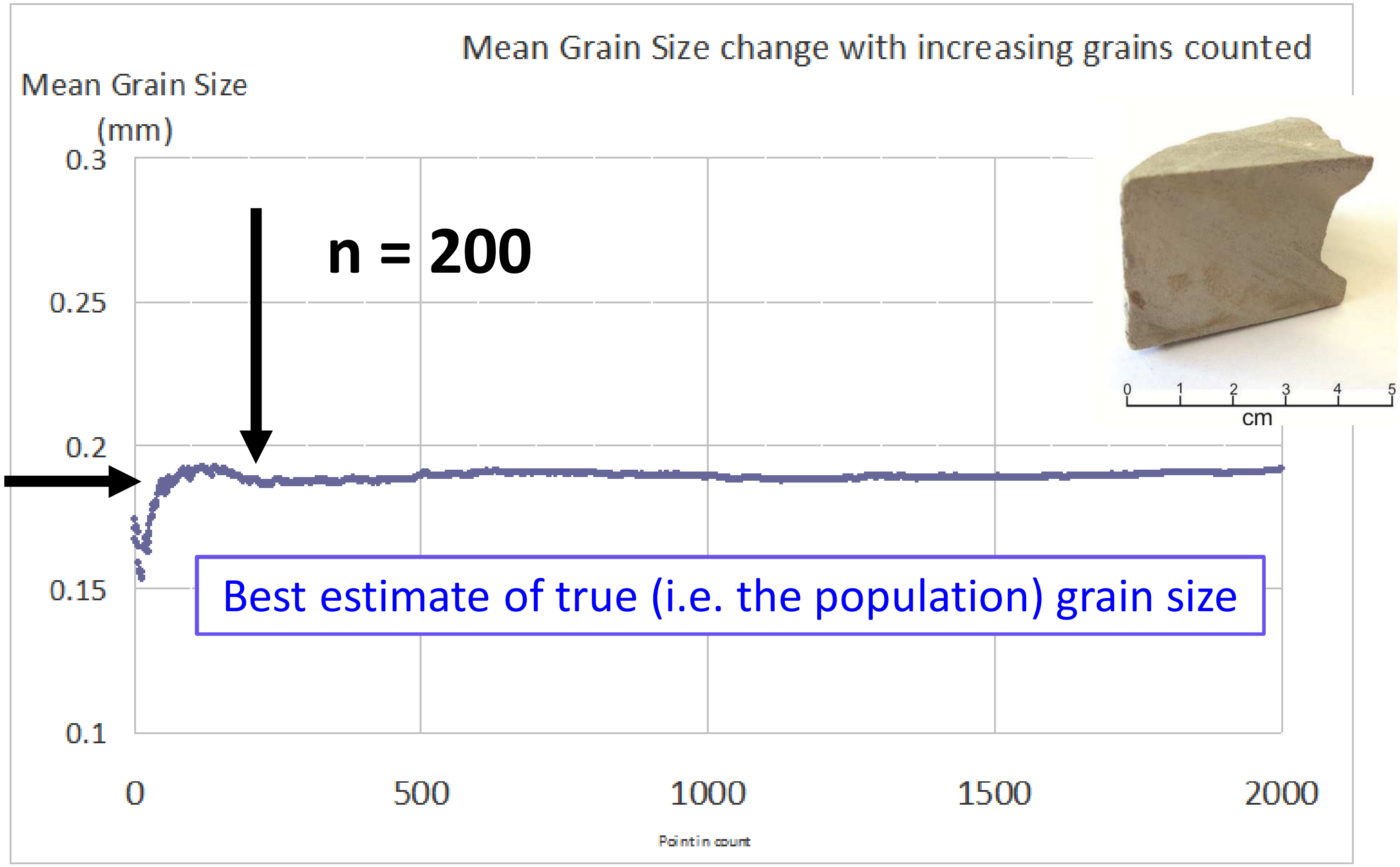
When using data in an analysis, we should know the confidence in each data type. The confidence in grain size distribution parameters is the main purpose of this research.

How many Grains to Measure?

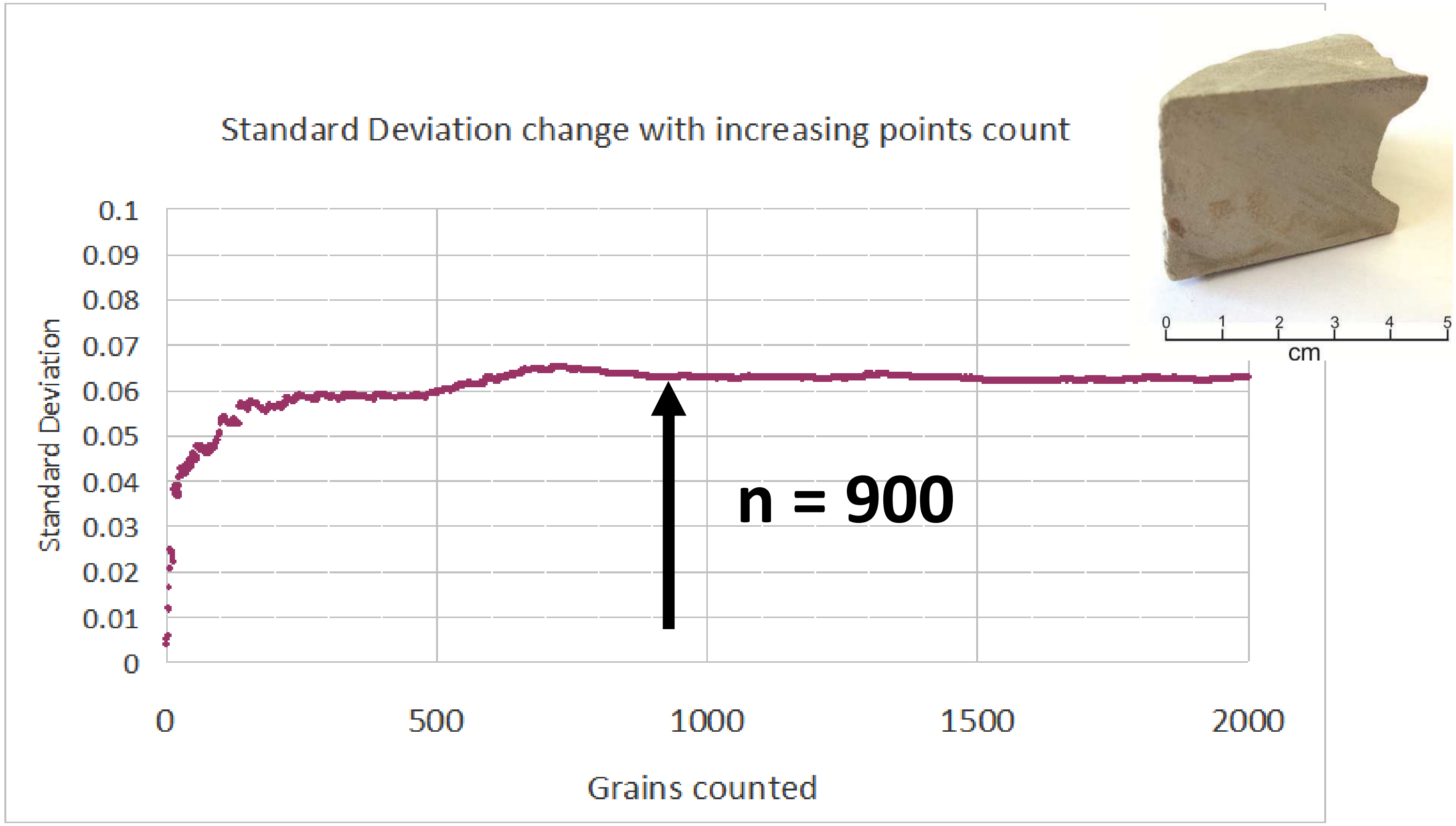
(Sample) Mean Grain Size changes as more grains are counted



The mean eventually settles on a value that we take to be a good approximation of the true value

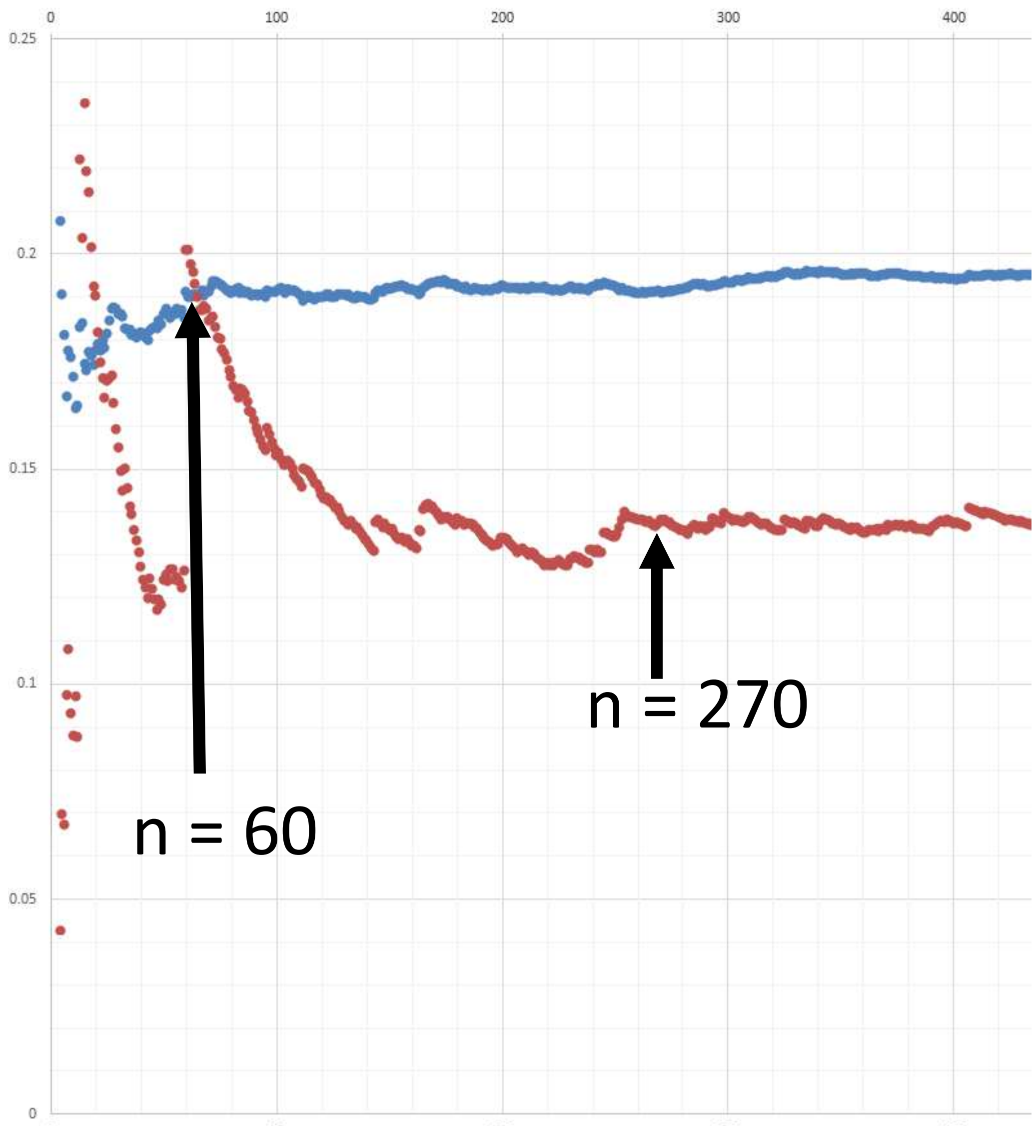


As more grains are counted, Standard Deviation changes differently to Mean



This is the same sample as above, where n = 200 was the minimum number of points needed for best estimate of mean grain size

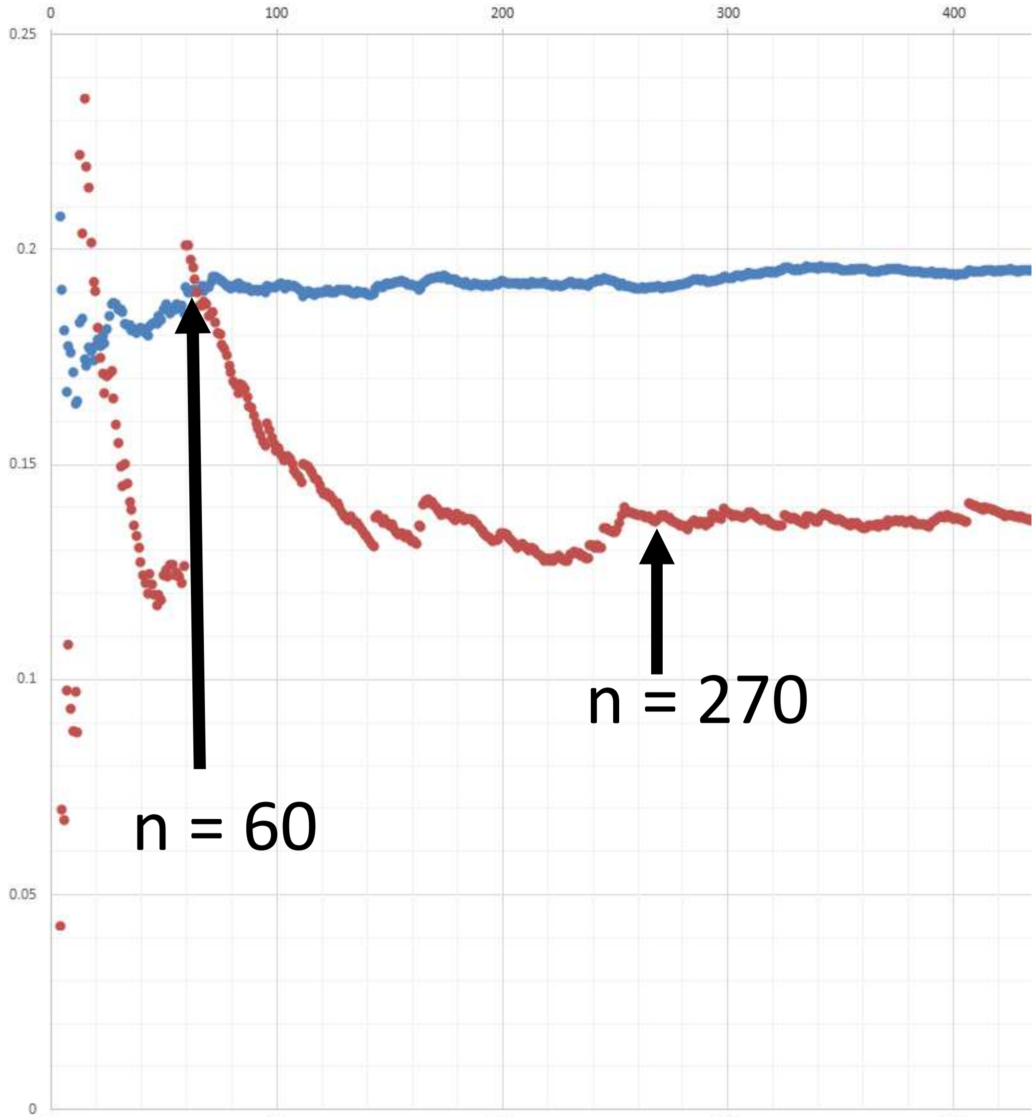
Data Collection Protocol: not universal values, but universal principles



Mean settles to a consistent value after ~ 60 points

Standard deviation requires more points to settle to a consistent value

Data Collection Protocol: not universal values, but universal principles



Mean settles to a consistent value after ~ 60 points

Standard deviation requires more points to settle to a consistent value

First sample:

Mean: after 200 points

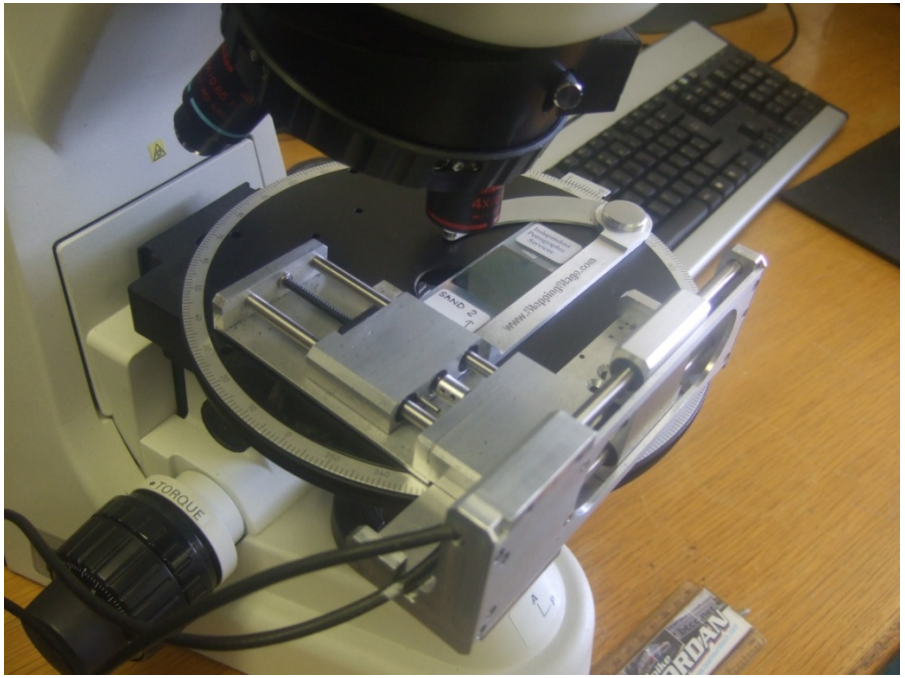
Standard deviation: after 900 points

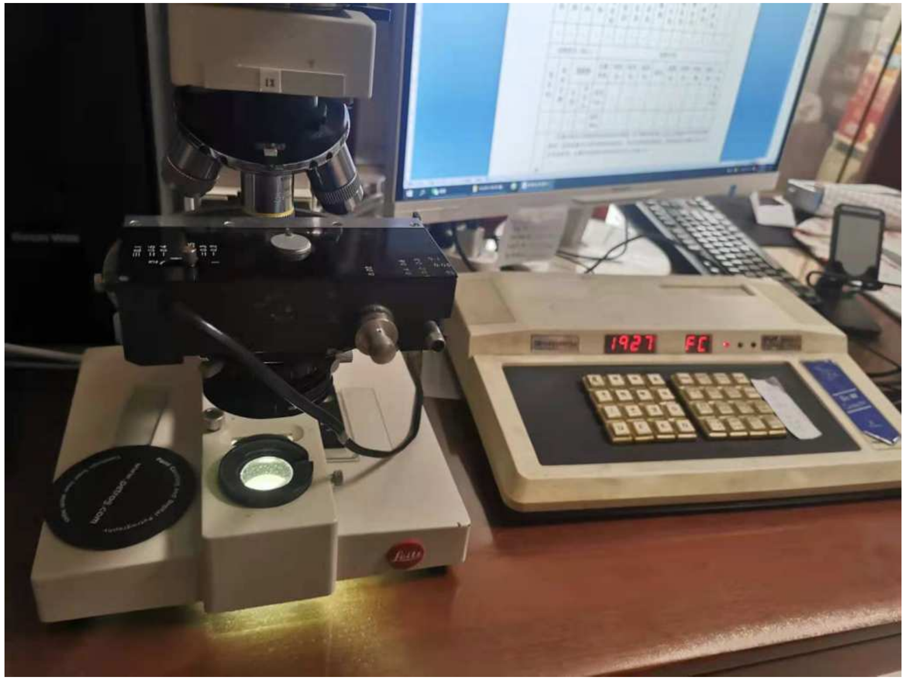
Summary and Conclusions

- Reservoir assessments (mostly) do not adequately account for variability; there are many reasons for this, both subjective and objective.
- Data collection protocols must be set separately for data intended for analysis of first and second moments (mean and variance).
- Because variance (standard deviation, sorting) is the primary variable of interest in Reservoir Quality Assessment, the number of measurements required to achieve an acceptable level of confidence is much greater than that generally used within the E&P industry, which has been determined (if at all) from what is required for estimating the mean.

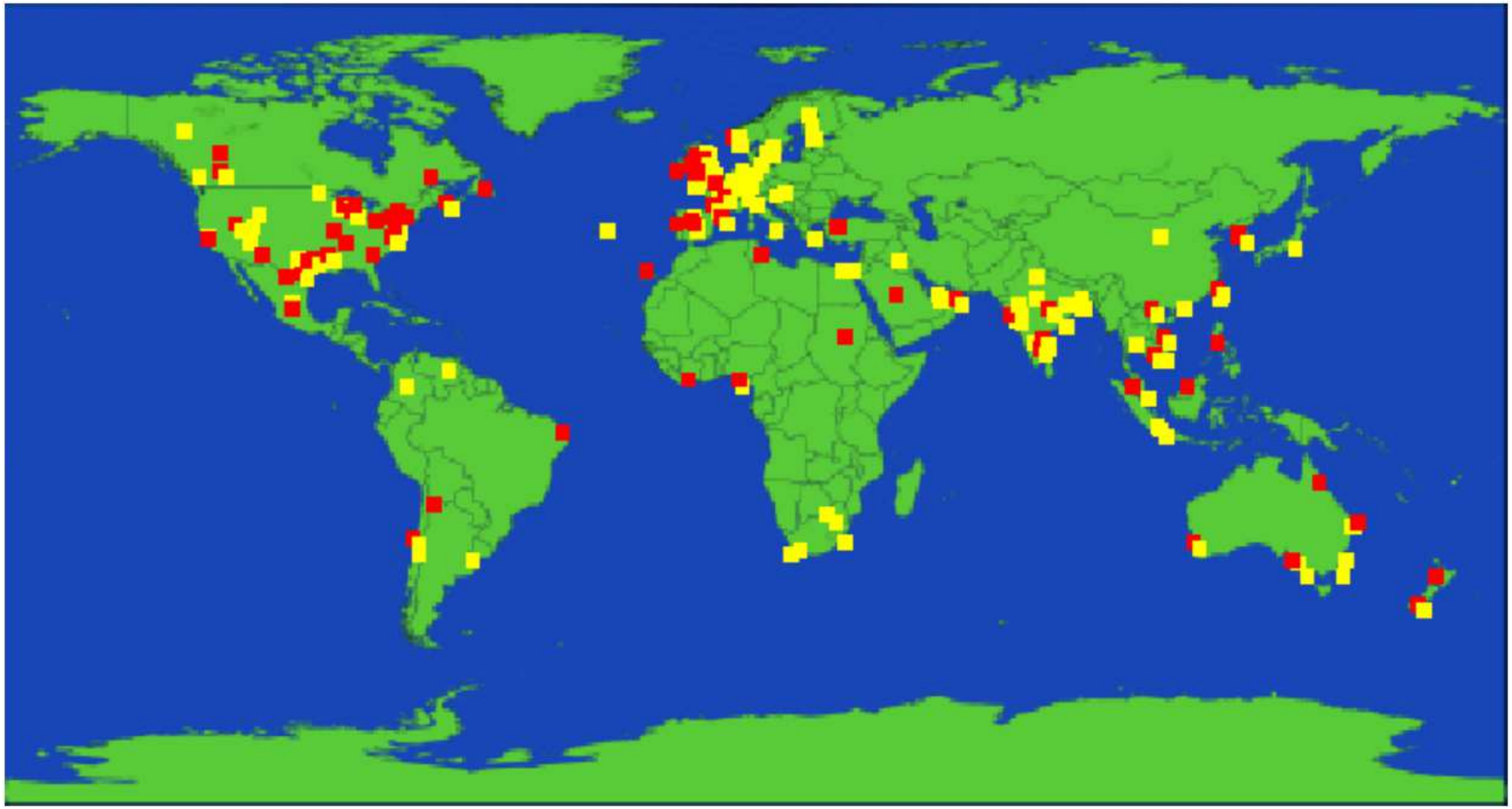
Use of Technology

The technologies we use influence the methods we choose. PETROG not only helps collect and analyse textural data, but also provides support through the entire petrographic process. By collecting compositional and textural data concurrently, grain size distributions may be estimated for each grain type separately or for any arbitrary grouping of grain types.





Thank you for listening！



Thank you for listening！

王鑫涛（**Xintao Wang**）

e-mail address: ds07069101@163.com;
Wechat（微信）: Geowissenschaften
Mobile phone Nr.: +86 15165267951

The Faculty of Geoscience and Geography, University of Goettingen, Goldschmidtstr.3, D-37077 Goettingen, Germany