CORE STRUCTURAL ANALYSIS & FRACTURE GONIOMETRY

TECHNICAL NOTES

PREPARED FOR,

GENERIC EXAMPLE

BY,

CORIAS

1. INTRODUCTION

Corias brings vast experience in high precision core reorientation, fracture description and structural analysis, with invaluable local experience all over the world.

We have managed many projects that included onsite core fracture description & structural analysis as well as studies that were performed on old cores in the core store.

Among the main deliverables is the prediction of the optimum drilling direction from oriented core studies, thus intercepting the fracture network to maximize reservoir performance, whether enhancing production or for more effective stimulation.

The ***Corias*** high precision ***AS-3D*** computer goniometry system is a portable structural analyser that allows performing the work immediately at the rigsite, maintaining the integrity of core samples before the core is cut and transported.

This proven approach ensures very reliable and highly accurate results to provide ***real time structural analysis*** and significant rig time savings. Alternatively, the *AS-3D* computer goniometer could be used for Fracture Goniometry and data acquisition in any core store / laboratory.

View of AS3D equipment in the corestore

2. STUDY OF TECTONIC & SEDIMENTARY STRUCTURES

FRACTURE LOGGING & DESCRIPTION – AIM OF THE STUDY

The study will be dedicated to acquire all necessary data, such as: Structures distribution, porosity, fillings, and directional parameters, etc…

And evaluate the implication of fracture systems into reservoir behavior.

2.1. FRACTURE LOGGING

Description and interpretation of all planar and linear structures, such as:

Tectonic Features: Natural Fractures, Stress-Related Features, Induced fractures.

Sedimentary Features: Dissolution seams, Stylolites, Joints, Bedding, and Disconformities, etc.

A comprehensive Micro tectonic study, based on an inventory of main structural events affecting the cored section.

The analysis consists of a systematic measurement of planar and linear structures implicated in the reservoir behavior. The study lays on the characterization of:

Type of discontinuities, location of structures, distribution, density, spacing, true frequency. Length of features, apertures, continuity, abutting, …

First relative orientation and dip Vs core axis, and then the orientation will be further calibrated with information from oriented core, borehole images, seismic maps, etc.

Description of mineralization or fillings. Stylolites and their contribution to reservoir anisotropy. Induced fractures and in-situ horizontal actual stress.

The AS3D computer aided 3D digitization equipment is considered as the most sophisticated geometric measurement system (linear and planar structures) for the study of cores.

The AS3D system is characterized by:

- Accuracy to the nearest degree, the quality of flatness gives information about the quality of the measure;
- The determination of structure's altitude at the nearest millimeter;
- Sophisticated menu-driven software which makes the acquisition easier;
- The quality of the data restoration, including: dipmeter logs, stereograms, rose diagrams, and histograms.

Moreover, the system ensures permanent data control, with great many proven case histories.

2.2. ANALYSIS PROCESS AND METHODOLOGY

The work typically includes the following three steps: *Acquisition*, *Processing, and Restitution* of geological data in usable document.

The process executed on cores consists of an exhaustive collection of the sedimentary and tectonic structures in order to obtain a dip-meter log, showing orientation and position of the measured structures.

The data recording is made using computerized equipment, which allows, by three-dimensional digitization, a direct acquisition of planar and linear structures on cores.

The orientation of the structures is first calculated in relation to a reference scribe line, and then reoriented in the real geographic position.

- With an oriented core, the geographic orientation of the structures is calculated immediately, using the orienting data.
- With a non-oriented core, the reorientation is done using statistic investigations and by comparison with logging data (FMI, DSI, FMS, CBIL, BHTV). If the logs are not available, other information from various sources (seismic structural dip, borehole deviation, etc.) can be used to determine the real position of the measured structures.

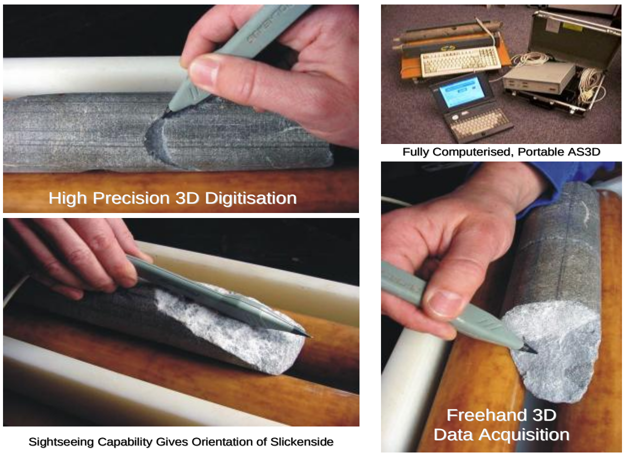


Figure 2 AS3D: Fully Computerised 3 Dimensional Electromagnetic Digitisation Goniometry System

	A	B	C	D	E	F	G	H	I	J
1	Depth	Azimuth	Dip	Length	Depth	Nature	Thickness	Effective	Filling 1	Percent of
2	in feet				in meter			opening		filling 1
3	9515,866	206	8	9,6	2900,436	Stratification joint	2		A	100
4	9515,981	358	7	9,6	2900,471	Stratification joint	5		A	100
5	9516,470	157	13	9,8	2900,62	Disconformity	0,5		A	100
6	9516,532	111	3	9,5	2900,639	Disconformity	0,5		A	100
7	9517,087	215	19	10	2900,808	Disconformity	0,2		A	100
8	9517,264	126	85	5,1	2900,862	Partially open frac	0,1	0,02	G	100
9	9517,280	102	70	3,8	2900,867	Partially open frac	0,1	0,02	G	100
10	9517,326	125	68	4,1	2900,881	Partially open frac	0,1	0,02	G	100
11	9517,372	86	15	9,8	2900,895	Bedding				
12	9517,392	75	19	10	2900,901	Bedding				
13	9517,448	79	19	10	2900,918	Open Fracture				
14	9518,261	285	75	3,4	2901,166	Partially open frac	0,2		G	100
15	9518,271	109	84	3,8	2901,169	Partially open frac	0,2		G	100
16	9518,274	290	89	3,8	2901,17	Partially open frac	0,2		G	100
17	9518,894	82	17	9,9	2901,359	Bedding				
18	9518,960	94	15	9,8	2901,379	Bedding				
19	9519,150	105	11	9,7	2901,437	Disconformity	1		A	100
20	9519,485	202	2	9,5	2901,539	Stratification joint	0,5		A	100
21	9519,567	227	6	9,6	2901,564	Stratification joint	0,5		A	100
22	9519,573	240	3	9,5	2901,566	Stratification joint	0,5		A	100

Figure 1 Example Database. Recorded Typologies & Geometrical Characteristics

2.3. DATA ACQUISITION

Graphical Outputs

Data are set out:

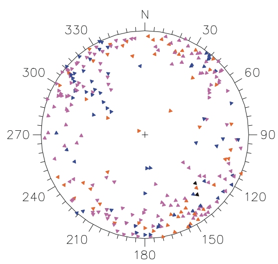
- As Logs: Dipmeter logs.

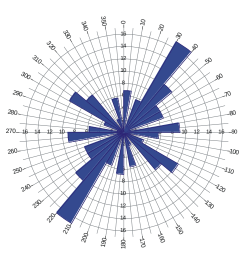
On the logs and diagrams, a color and shape code is used to distinguish:

➢ Sedimentary structures like bedding and cross bedding, stratification planes, clay joints, straitform stylolitic joints, and erosion contacts. Tectonic structures like fractures, gashes, and tectonic stylolitic joints.

- As Rose Diagram:

➢ Which set out azimuth or orientation organizations.





- As Frequency Histograms:

➢ Which set out the dip organizations.

- As Stereonet Plots:
- As Composite Log:

Highly broken zones that are impossible to reconstitute are not included in the survey, to allow a good reliability indispensable for the reorientation operations. These zones are included as remark in the study and diagrams.

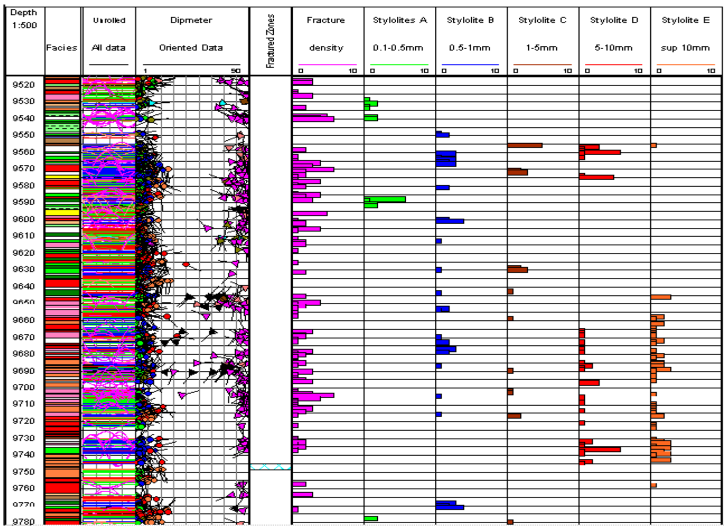


Figure 3 Example of Composite Log

3. INTEGRATION OF CORE RESULTS & IMAGES LOGS

When image logs are available, a comparison between Core structural analysis / fracture description results and image log data is made for the cored interval. The aim of the comparison study is to find out the main differences between both methods of analysis, with the objective to calibrate and aid better interpretation of image log data in the non cored interval.

To perform the analysis, different kinds of diagrams will be plotted and the orientation and organization of each are compared..

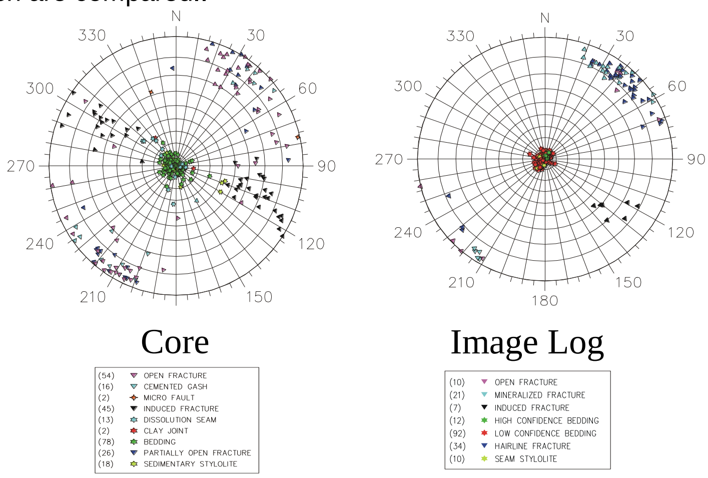


Figure 4. Example of stereonets from Core Vs Image Log. Data Integration. Case History

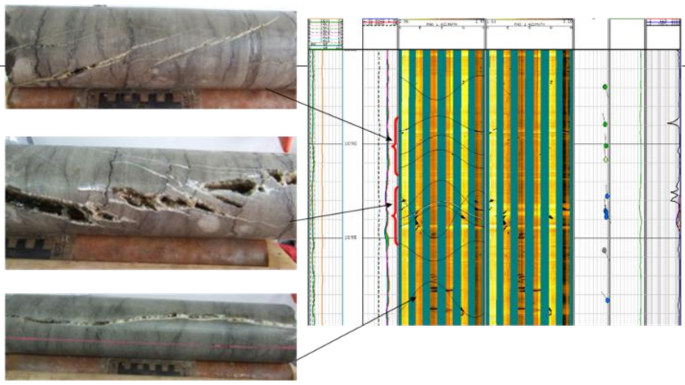


Figure 5 Core Vs Image Logs, Integrating Core Photos & Core Data for Image Calibration

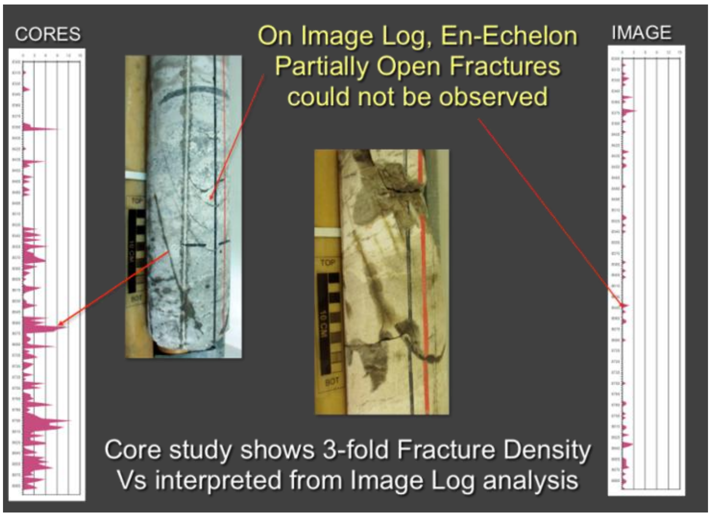


Figure 6 Many 'En Echelon' Natural Fractures did not appear on Image Log, Leading to Unrepresentative Fracture Density (Case History[1]).

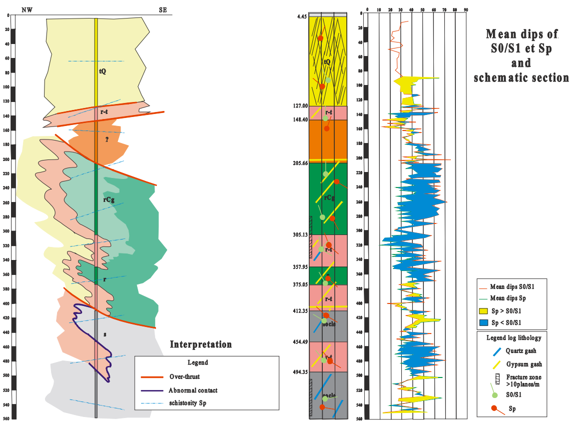


Figure 7 Example of schematic section and logs from basement cores.

4. KEY DELIVERABLES

Quick and reliable reorientation of tectonic and sedimentary structures.

- Real time output; with elaboration of graphic outputs and producing all required graphs and plots including Dipmeter logs, Rose diagrams, Stereonet plots and other specific diagrams, etc., shortly after data acquisition.
- Characterization of natural fracture connectivity by utilizing information on fracture orientation, fracture size and fracture density.
- Reliable orientation of stress-related induced fractures, and full use and integration of well deviation data in relation to formation features, to determine the following:
- Relation with in-situ horizontal stress.
- Relation between induced and natural fractures.

Composite structural log with integration of available logs.

Comprehensive study with deformation mechanisms and timing.

Detail photographs of characteristic features.

Comprehensive electronic database.

5. OPTIONAL

Fracture porosity and permeability calculation from core collected data. Predict optimum drilling direction from oriented cores to maximize reservoir performance. (Methodology available)

Paleostress axis deduced from slickenside on fault planes.