VINCI TECHNOLOGIES
Laboratory and field instruments for Petroleum Industry

ISO 9001 BUREAU VERITAS Certification

GEOCHEMICAL CALCULATION SOFTWARE

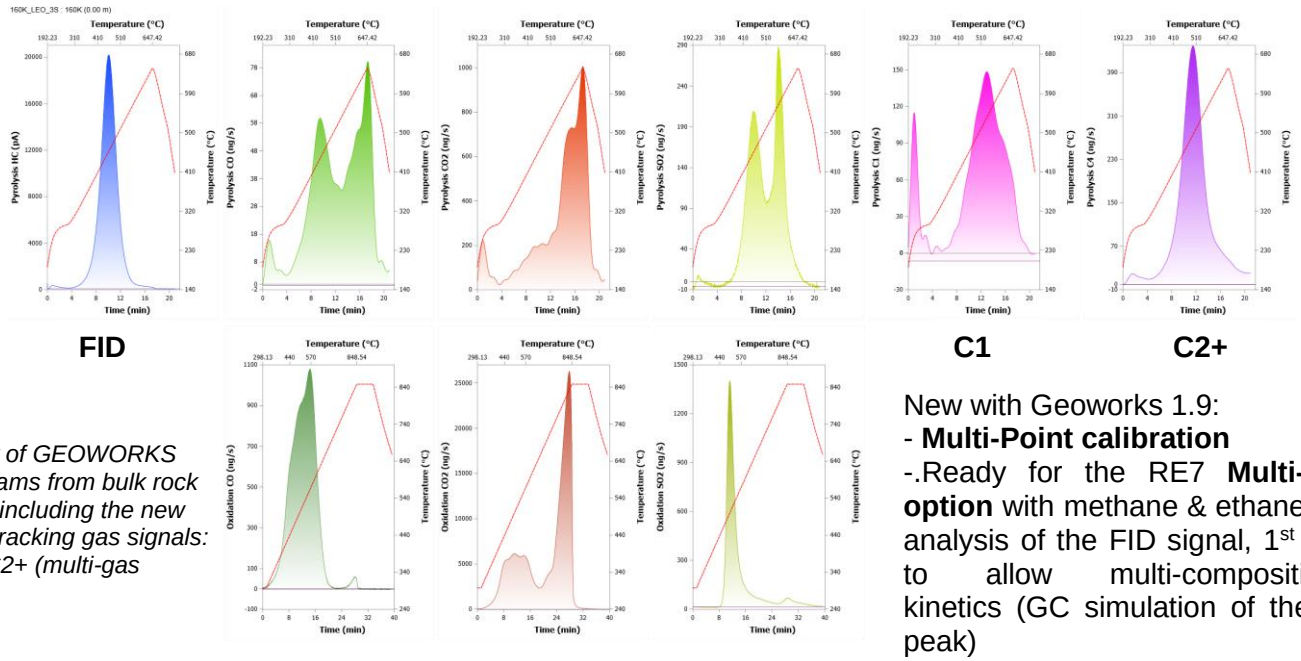
Geoworks™

Geoworks® is Vinci Technologies **latest geochemical analysis software suite**. The main purpose of the application is the raw data acquisition, visualization, and potential correction using interactive cursors and specialized modules. **Seven different analysis methods** are available to account for sample nature: bulk rock, kerogen (pure organic matter), reservoir, (pure) oil, coal, gas shale, and multi-heating rate. Geoworks core module includes all the features of the Rock-Eval Reader (cf. brochure).

Geoworks® results and calculations have immediate relevance in well to well correlation, and data comparison.

The following modules can be added to complete the functionalities of the software base:

- **Study module**
- **Simulated distillation module**
- **Quick-kinetics module**
- **Multi-kinetics module**
- **CleanSim module**
- **Quick modelling module**
- **Soil module**
- **HTML reports module**



FID **C1** **C2+**

Overview of GEOWORKS thermograms from bulk rock analysis, including the new primary cracking gas signals: C1 and C2+ (multi-gas option).

New with Geoworks 1.9:
- **Multi-Point calibration**
-.Ready for the RE7 **Multi-Gas option** with methane & ethane+ IR analysis of the FID signal, 1st step to allow multi-compositional kinetics (GC simulation of the S2 peak)

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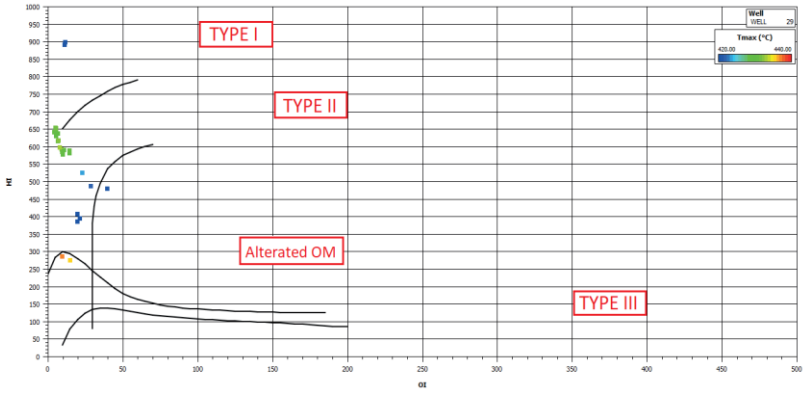
The most notable differences between Geoworks® and previous software are a flexible, user-friendly interface and file storage process, compatibility with Windows 64 bits operating systems, the visualization of sulfur dioxide parameters (pyrolysis & oxidation), multi-gas parameters, automatic window sizing, kinetics, quick modelling, online reports and online help with our qualified engineers.

Geoworks® covers the different methods of analysis to take into account the nature of the samples through calculations facilitating the automated determination of:

- Type, quality and quantity of kerogen,
- Light oil, heavy oil and NSO compounds quantities in reservoirs
- Organic and Mineral Sulfur (pyrite & sulfates)
- Shale gas interpretation: total quantities of gas and oil generated (free and adsorbed gas)
- **Multi-point calibration for all signals (FID, CO, CO2, SO2, C1, C2+)**
- Analyses subtraction, for mud fraction removal

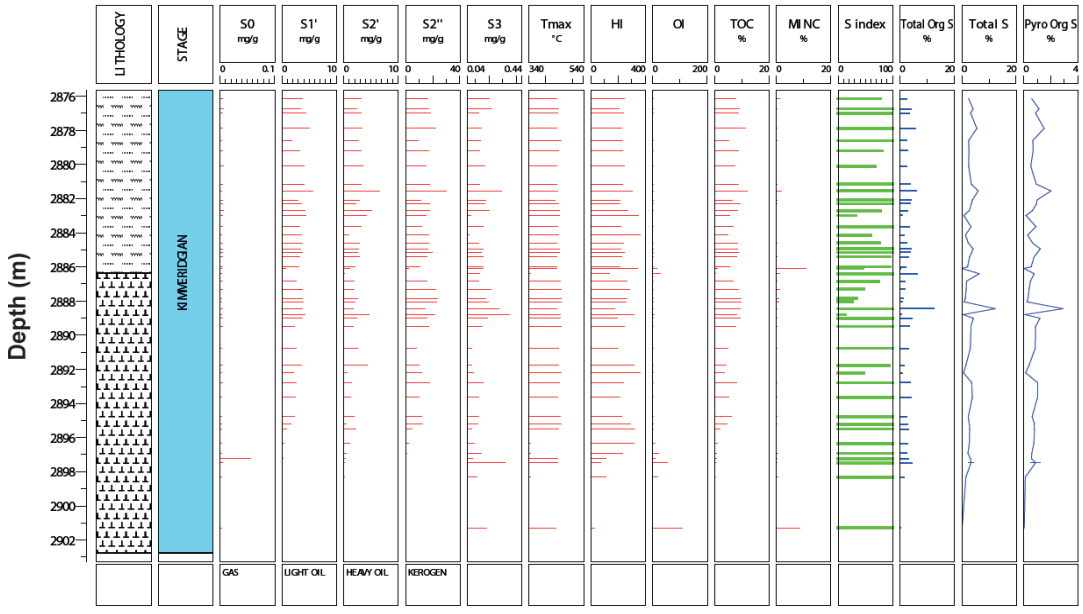
STUDY MODULE

The software study module allows users to go beyond simple screening of results. It unlocks the possibility to **manipulate data** (add, delete and merge wells and parameters, customize tables, etc.) and enhance it either in the form of **predefined** (such as Van Krevelen) or **customized diagrams**.



*Example of a Van Krevelen diagram with a third parameter included: **Tmax**.*

Geochemical logs, **litho-stratigraphic columns** and **reports** in **metric and/or imperial units** also fall within the scope of the Study module.



Example of a custom log made with Geoworks® study module.

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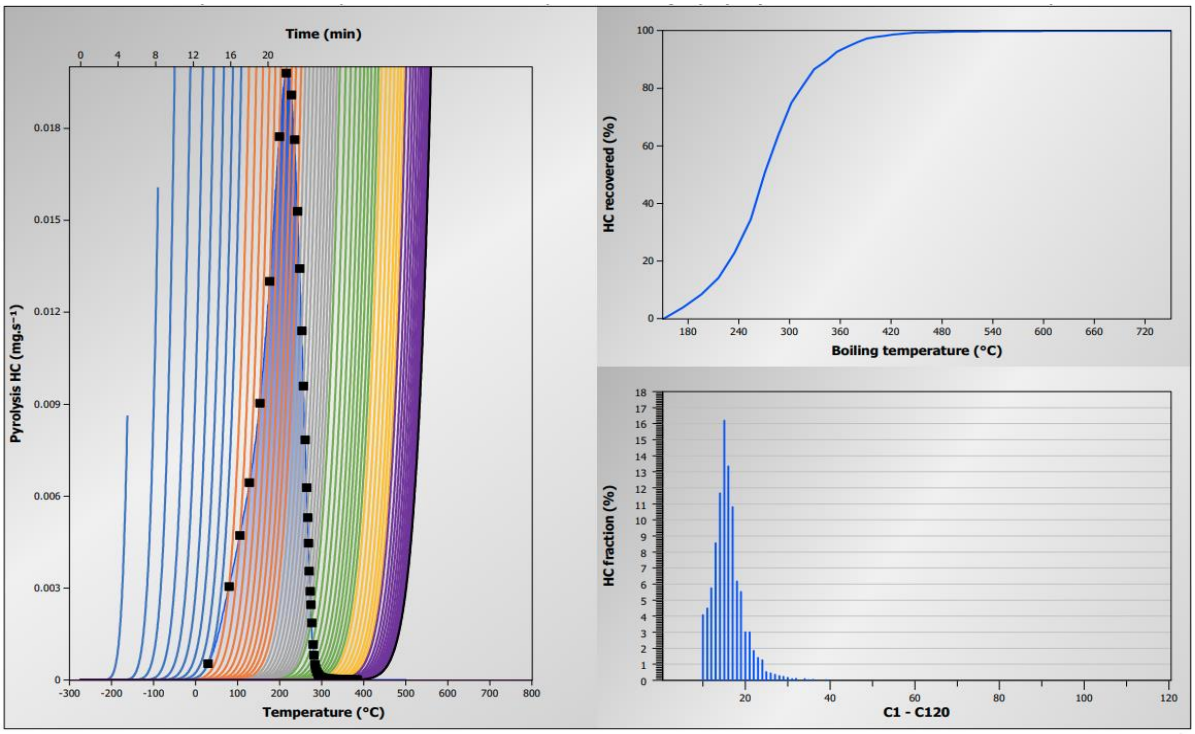
SIMULATED DISTILLATION MODULE

This functionality makes it possible to identify the different alkanes **(C1 to C120)** of an oil contained in a reservoir. It highlights the **distribution diagram** as well as the **simulated distillation curve** of the oil contained in the sample.



Geoworks® "Simulated Distillation" module is used for rapid determination of an in-situ oil composition.

The computation is based on the **Antoine's equation curves** which describes the evolution of the n-alkane hydrocarbons physical change of state for (C1-C120) with a single heating rate (°C/min).

	n-Ci	Teb (°C)	Cumul. %	%	mg	Parameters
1	1	-162	0.00	0.00	0.000	**n-Ci min**
2	2	-89	0.00	0.00	0.000	1
3	3	-42	0.00	0.00	0.000	**n-Ci max**
4	4	-0.5	0.00	0.00	0.000	120
5	5	36	0.00	0.00	0.000	**Analyzer**
6	6	69	0.00	0.00	0.000	RE6
7	7	98	0.00	0.00	0.000	**Vol. flow (ml/min)**
8	8	126	0.00	0.00	0.000	100
9	9	151	0.01	0.01	0.000	**Gradient (°C/min)**
10	10	174	4.08	4.08	0.241	22.3047
11	11	196	8.59	4.51	0.267	**M (g/mol)**
12	12	216	14.34	5.75	0.340	226.035
13	13	235	22.92	8.58	0.507	**IBP (°C) - C9**
14	14	254	34.60	11.69	0.691	151
15	15	271	50.82	16.21	0.959	**FBP (°C) - C61**
16	16	287	64.17	13.35	0.790	623.9
17	17	302	74.99	10.82	0.640	
18	18	316	81.16	6.17	0.365	
19	19	329	86.69	5.53	0.327	
20	20	344	89.70	3.01	0.178	
21	21	356	92.72	3.02	0.179	
22	22	369	94.58	1.86	0.110	
23	23	380	96.00	1.42	0.084	
24	24	391	97.27	1.27	0.075	
25	25	402	97.80	0.53	0.031	
26	26	412	98.24	0.44	0.026	
27	27	422	98.60	0.36	0.021	
28	28	431	98.89	0.29	0.017	
29	29	440	99.13	0.24	0.014	
30	30	449	99.31	0.17	0.010	

Patent pending
Simulation of a GC run of the S1 signal…
Including heavy oil with C100+ fractions

This module provides also parameters about the oil content as **average molecular weight**, **initial boiling point** (IBP) and **final boiling point** (FBP).

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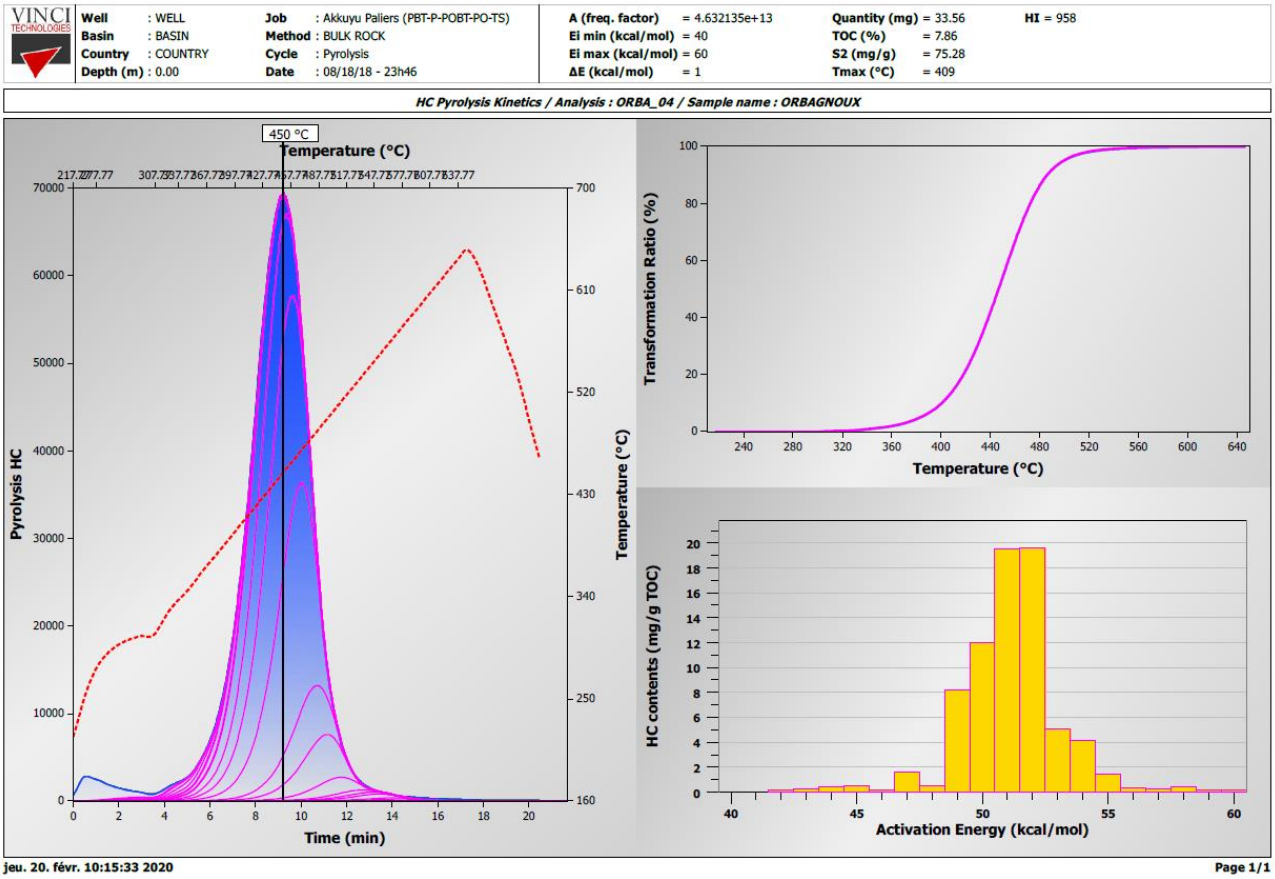
QUICK-KINETICS MODULE

Based on the **Tissot-Espitalié model, using the Arrhenius equation,** this module allows rapid **determination of activation energies distribution** for **S2** and **sulfur peaks** obtained by pyrolysis **single heating rate analysis** (typically 25°C/min).



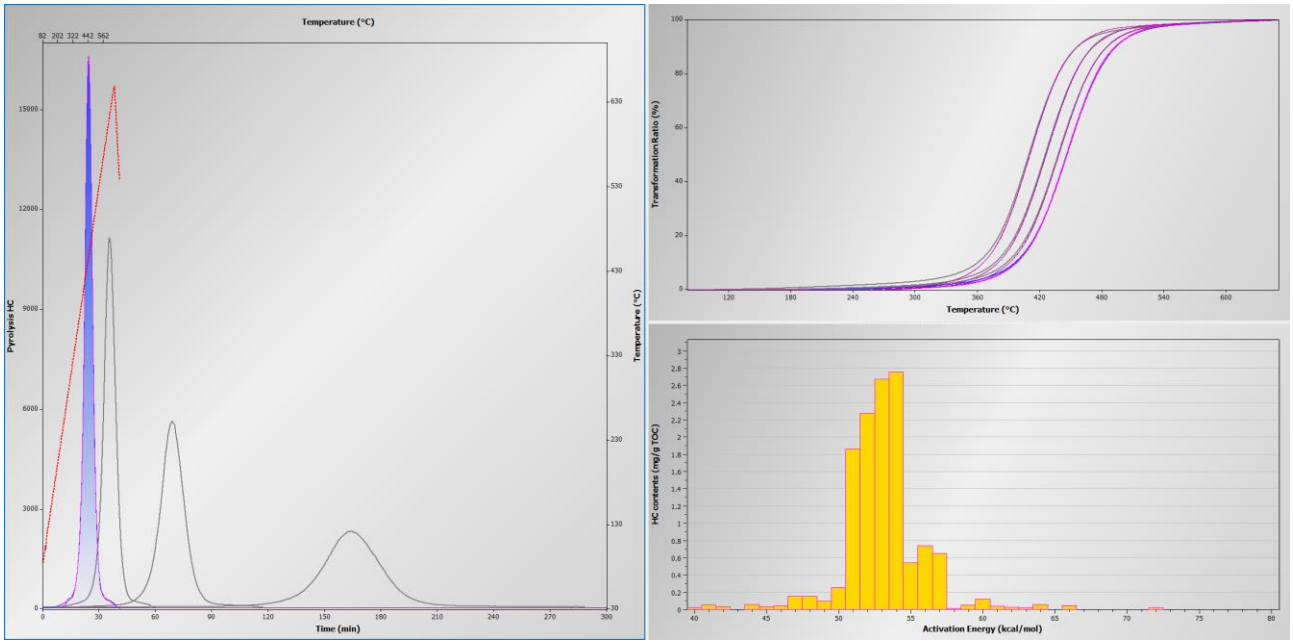
Geoworks® "Quick Kinetics" module used for rapid determination of activation energies distribution for S2 peak. (this screenshot also shows Geoworks® printing mode with its customizable print header)

	Ei (kcal/mol)	%	mg/g TOC	Parameters
1	40	0.00		**Emin (kcal/...**
2	41	0.00		40
3	42	0.19	1.82	**Emax (kcal/...**
4	43	0.39	3.75	60
5	44	0.55	5.28	**DeltaE (kcal...**
6	45	0.70	6.70	1
7	46	0.25	2.44	**A**
8	47	2.10	20.07	4.632135e+13
9	48	0.72	6.88	**Residual Error**
10	49	10.94	104.81	2.499323e-07
11	50	15.96	152.85	**kS2 (mg/g)**
12	51	26.00	249.06	75.28
13	52	26.14	250.46	**kHI (mg/g T...**
14	53	6.80	65.17	958
15	54	5.56	53.27	
16	55	1.95	18.68	
17	56	0.46	4.39	
18	57	0.32	3.06	
19	58	0.56	5.34	
20	59	0.18	1.70	
21	60	0.23	2.25	

It is possible to **set a frequency factor A or to let the software optimize it in a chosen range**. **Many other computing options** are **available** and allow users to fit kinetic studies in a detailed and precise manner. All the numerical values which result from the kinetic calculations are made available in specific tables.

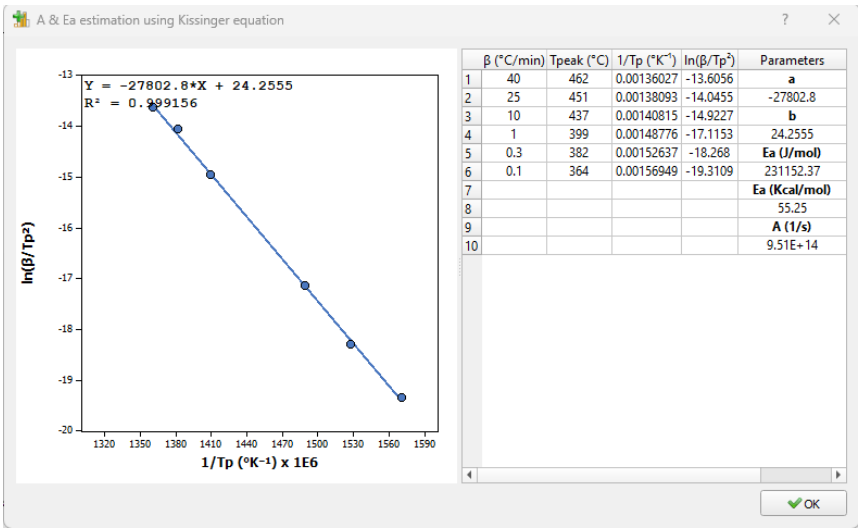
MULTI KINETICS MODULE

This module has the same functions as the Quick Kinetics module but is **based on several analyses of the same sample at different or identical heating rates**. In the scientific literature, opinions are mixed on the type of kinetics to be used, which is why both options are available in Geoworks® software. The Quick Kinetics method will be faster to execute when the Multi Kinetics method may give **more accurate results** but will require more analyses beforehand.



Geoworks® "Multi Kinetics" results for the same sample at different heating rates

	Ei (kcal/mol)	%	mg/g TOC	Parameters
1	40	0.60	6.92	**Emin (kcal/...**
2	41	0.17	1.94	40
3	42	0.23	2.71	**Emax (kcal/...**
4	43	0.24	2.78	70
5	44	0.42	4.86	**DeltaE (kcal...**
6	45	1.09	12.68	1
7	46	0.66	7.65	**A**
8	47	0.00		3.611109e+13
9	48	2.92	33.88	**Residual Error**
10	49	4.67	54.20	1.564247e-06
11	50	15.80	183.25	**kS2 (mg/g)**
12	51	24.13	279.90	12.91
13	52	22.44	260.23	**kHI (mg/g T...**
14	53	5.41	62.80	1148
15	54	14.25	165.29	
16	55	0.59	6.79	
17	56	1.00	11.55	
18	57	2.43	28.24	
19	58	0.19	2.23	
20	59	0.26	2.99	
21	60	0.21	2.49	
22	61	0.52	6.07	
23	62	0.00		
24	63	0.37	4.23	
25	64	0.21	2.39	
26	65	0.00		
27	66	0.00		
28	67	0.00		
29	68	0.00		
30	69	0.00		
31	70	1.18	1.76	



	β (°C/min)	Tpeak (°C)	1/Tp (°K⁻¹)	ln(β/Tp²)	Parameters
1	40	462	0.00136027	-13.6056	**a**
2	25	451	0.00138093	-14.0455	-27802.8
3	10	437	0.00140815	-14.9227	**b**
4	1	399	0.00148776	-17.1153	24.2555
5	0.3	382	0.00152637	-18.268	**Ea (J/mol)**
6	0.1	364	0.00156949	-19.3109	231152.37
7					**Ea (Kcal/mol)**
8					55.25
9					**A (1/s)**
10					9.51E+14

Kissinger equation (see Baudin et al 2023 for mathematical demonstration) available in the Multi-Kinetics module

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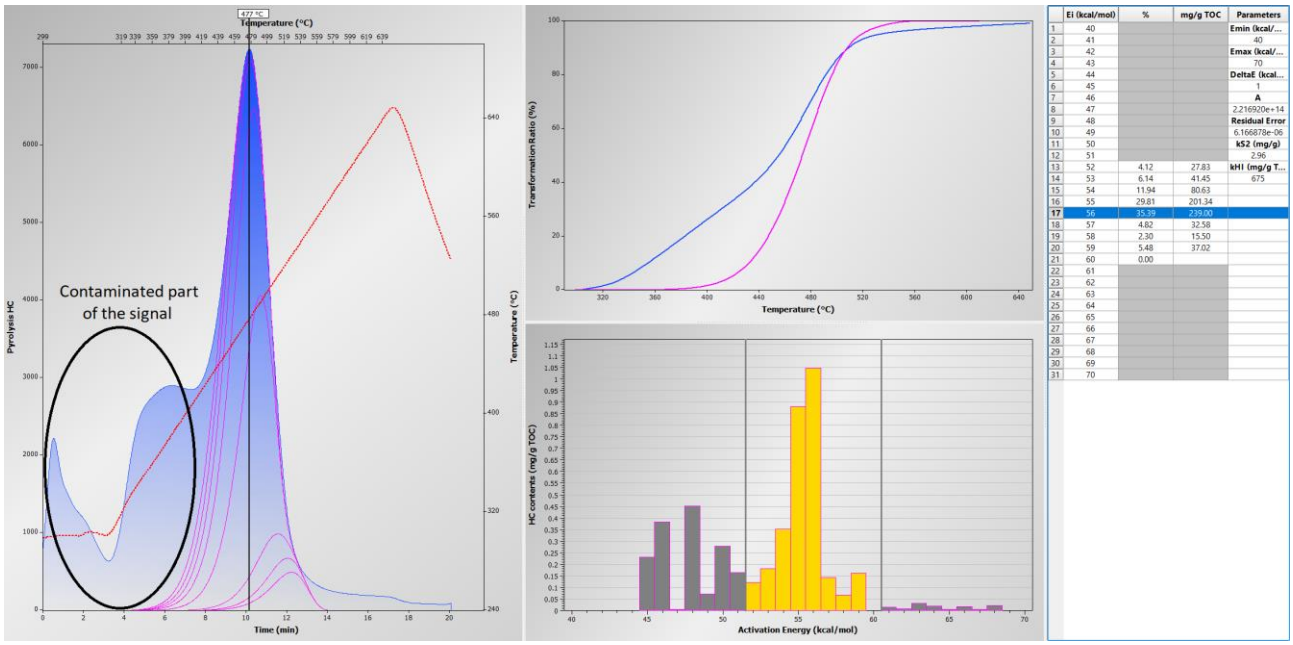
CLEAN-SIM MODULE

This module **simulates solvent/Soxhlet extraction** using Rock Eval data on cutting samples contaminated with oil-based mud or other free hydrocarbons. The corrected S2 peak is calculated by **deconvolution of the original S2 peak using cursors and kinetic parameters**.

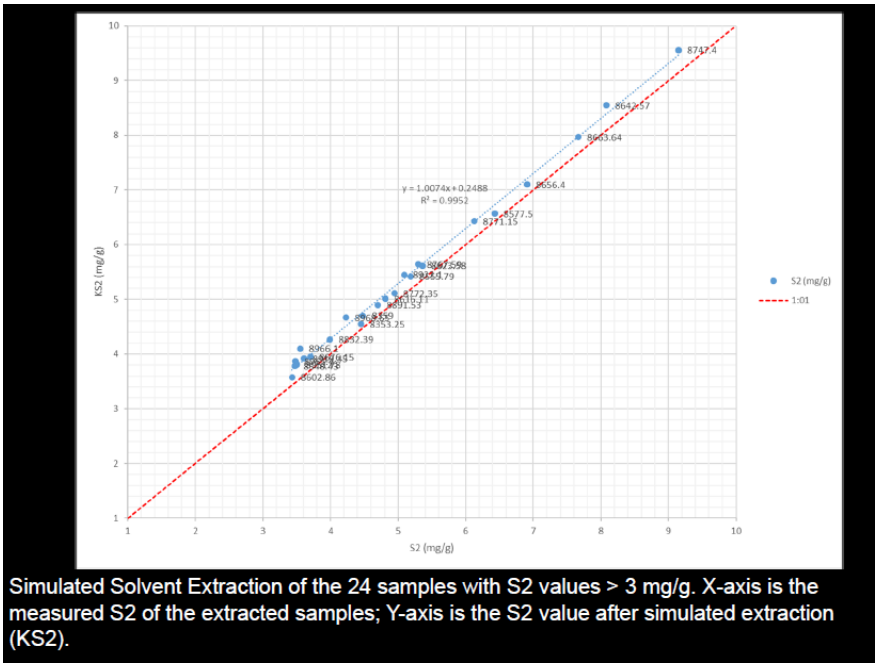
This module makes it possible to **clean samples without prior manipulation and in no time**.



➔ *Geoworks® CleanSIM module used to isolate S2 peak from drilling mud contamination.*

All the **recalculated parameters** (kS2, kHI, kTOC, kTmax, etc.) are available in generic tables gathering the results for all the samples studied to allow better data extraction and sharing.

The comparison between the results of a Soxhlet solvent extraction and the results of artificial extraction via Geoworks® CleanSIM module speaks for itself, with an excellent correlation of **0.9952**.



Simulated Solvent Extraction of the 24 samples with S2 values > 3 mg/g. X-axis is the measured S2 of the extracted samples; Y-axis is the S2 value after simulated extraction (KS2).

Correlation between CleanSIM module and Soxhlet solvent extraction results on 24 samples from the Permian Basin.

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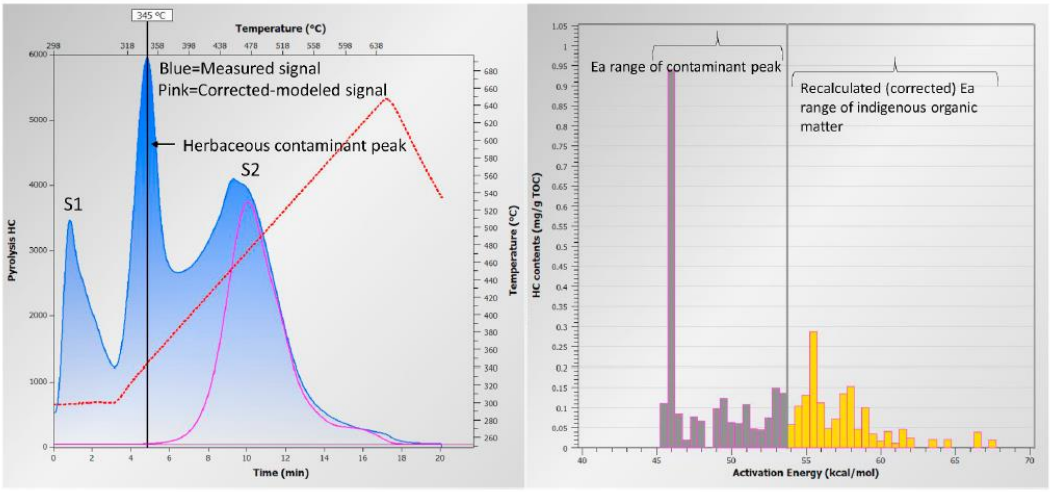
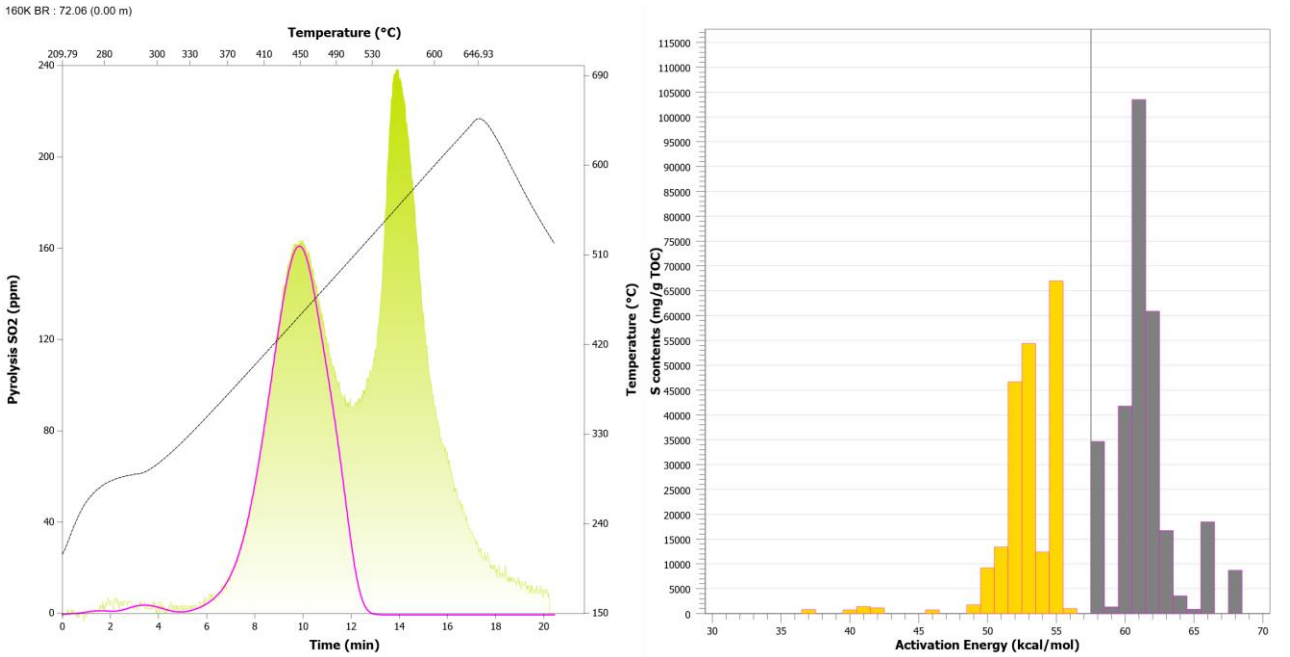


Fig. 9. An example of *CleanSim* recalculation of contaminant-free S_2 yields in sample 954 m (previously extracted with organic solvents), well B-114. Left panel shows the measured and modeled (deconvoluted) pyrolysis yields; right panel shows the distribution of E_a and E_a correction (removed E_a range in dark gray). See text for details. The E_a cut-off value of 53 kcal/mol was selected based on previous studies (e.g. Waples et al., 2010; Peters et al., 2015; Burnham, 2015; Burnham et al., 2018) showing that kerogen types I, II, and III (except for Type IIS) typically have E_a greater than the above value. E_a values less than 53 kcal/mol are the result of either the presence of bitumen or herbaceous solid contaminants.



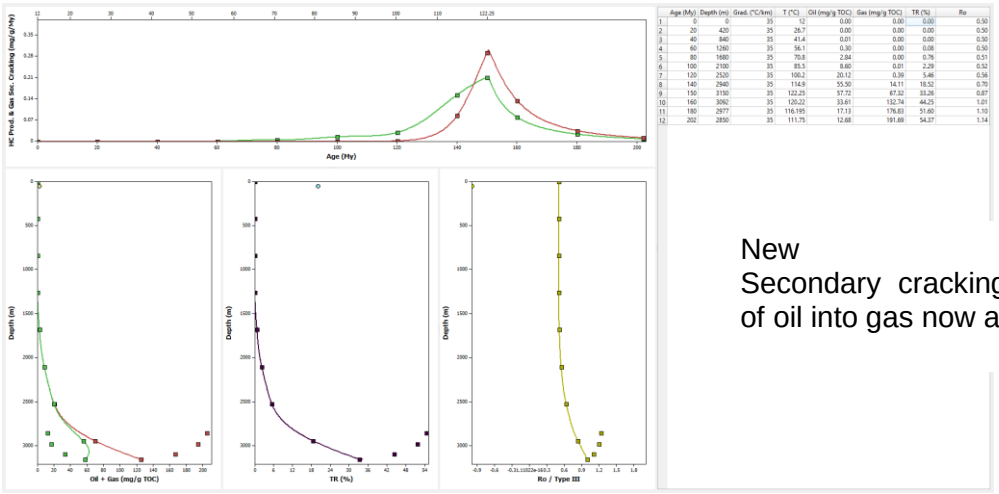
The algorithm can also be used to extract the signal sur to the pyrite peak, for better kinetics on organic sulfur pyrolysis

QUICK MODELLING MODULE

The Quick Modelling module is a very **effective tool for calibrating the kinetic parameters** obtained with **Quick or Multi-Heating Kinetics**. The idea is to use the kinetics and modelling modules simultaneously to best **simulate the production of a source rock in a specific basin**. Then compare the results with **field data to confirm the accuracy of the model and kinetic parameters**. Different combinations of kinetic parameters must be tested to get as close as possible to the collected basin data.

If the burial law of the basin studied is known (i.e. depth of formation, time scale and geothermal gradient), the Quick Modelling module can be used to calibrate the kinetics of the sample. But also

to determine the degree of maturity (Ro), simulated vitrinite reflectance (VRo%), transformation ratio (TR) and the quantities of hydrocarbons produced.
If the law of burial of the studied basin is unknown, the user can always use a sedimentary basin model with similar properties provided by Vinci as references for the module (i.e. Paris Basin) or add one.



Geoworks® Quick Modelling module used on a source rock from the Toarcian layer of the eastern edge of the Paris basin.

SOIL MODULE

This module allows to get Soil Organic Matter (SOM) quantity and quality, as well as Carbonate content in soil analyses from Rock-Eval.

The Rock-Eval + PartySOC model is emerging as a rapid and inexpensive method to assess SOM stability. PartySOC calculates the stable and active fractions of organic carbon, and these values can be considered as absolute values if they are measured on soils that are similar to those which were used to calibrate the model (ie soils from long term agronomical experiments under European pedoclimate conditions). They are applicable to agricultural soils, woodlands and grasslands. PartySOC has been applied on a diversity of soils samples from long-term agronomical experiments in temperate regions (Germany, Sweden, Finland, Denmark, Sweden, France, Spain, USA, Argentina, Australia, Canada) and several soil monitoring programs (French RMQS, German BZE, LUCAS toposoil…).

Partioning soil organic carbon to improve SOC dynamics simulations accuracy
Partitioning soil organic carbon (SOC) into two kinetically different fractions that are stable or active on a century scale is key for an improved monitoring of soil health and for more accurate models of the carbon cycle (Cécillon et al., 2018, 2021, Kanari et al., 2022). PartySoc can be used to initialize kinetic pools of soil C models, such AMG (Clivot et al 2019). Thus, PartySoc provides a quantified information on SOC biogeochemical stability.

TOC and MINC are comparable to TOC and TIC from Elemental Analysis (cf Stojanova et al 2024).

Additional information is available upon request.

HTML REPORTS MODULE

The module allows extraction of results in **.html** format, sharing of data in an ultra-light form and a quick review of the results in a predefined form of tables or interactive diagrams.

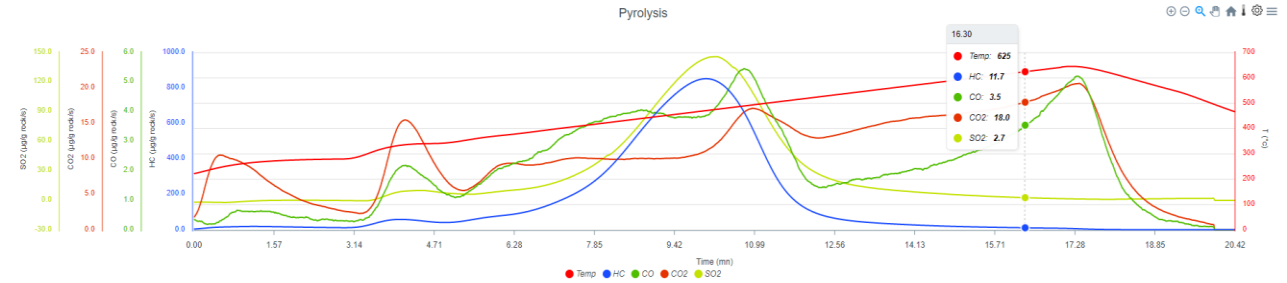
The output table is fully customizable, and the thermograms can be viewed easily (including user friendly zoom in, zoom out functions).

Compatible with smartphones and tablets.

Job report / Basic RockEval HC results

Analysis	Sample	Depth (m)	S1 (mg/g)	S2 (mg/g)	S3 (mg/g)	TOC (%)	HI	OI
IFP 160K_01	160000	0.00	0.17	12.42	0.79	3.30	376	24
IFP 160K_02	160000	0.00	0.17	12.39	0.79	3.31	374	24
IFP 160K_03	160000	0.00	0.17	12.29	0.78	3.29	374	24
IFP 160K_04	160000	0.00	0.17	12.59	0.77	3.30	381	23
IFP	160000	0.00	0.17	12.24	0.76	3.30	371	23
IFP1	160000	0.00	0.17	12.19	0.76	3.27	373	23

Analysis data / 93AK74-P_01



Dynamic report, with zoom in options, to view the thermograms

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