GEOIsotopes

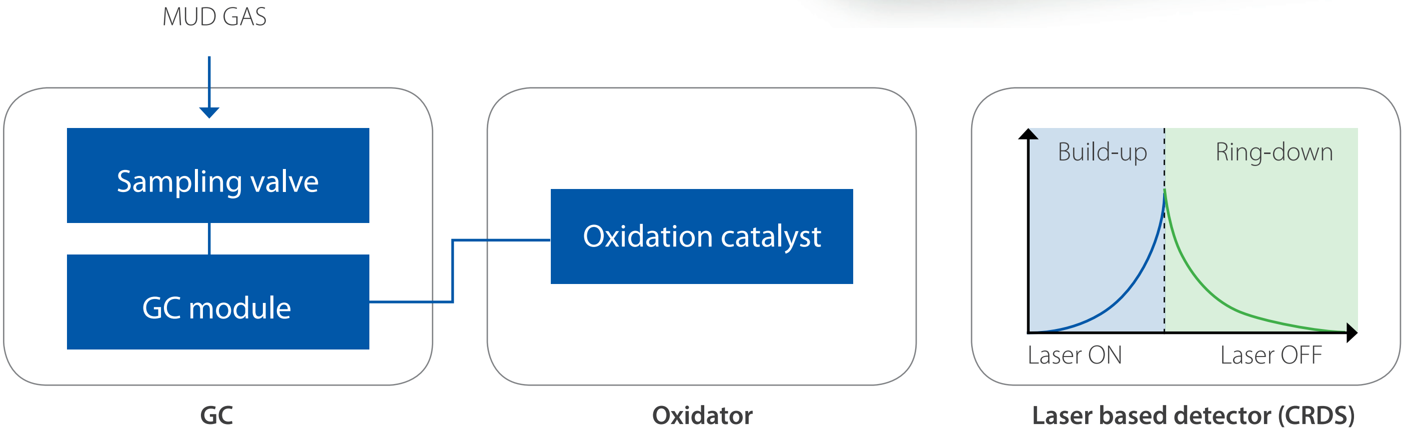
Real-Time isotopic analysis at rigsite, δ^{13} isotopes of C_1, C_2 and C_3

GEOTech
RESEARCH & LABORATORY

Introduction

Information gathered when characterising mud gases contributes to describing and understanding the downhole environment. An ongoing trend in the Oil&Gas industry is to move to the wellsite as many analyses as possible, leaving conventional laboratories the role of checking data quality and extending the characterisation using complementary technologies not yet available for field deployment. Often, the choice between these two approaches is a compromise between high frequency wellsite data available in the shortest time, set against higher accuracy/precision but delayed laboratory data.

Carbon isotopes are a leading constituent of this tendency, with increasing interest in moving their analysis to wellsite observed globally. This move creates a need for deeper characterization and comparison of laboratory and wellsite instruments.



The customised GC, performs hydrocarbon component separation, the oxidator then converts the hydrocarbons to CO2, which is then analysed by the CRDS laser, quantifying the $^{13}C/^{12}C$ ratio

Users of GeoIsotopes include the following:

bp, Chevron, ConocoPhillips, equinor, eni, Kuwait Oil Company, Mubadala Petroleum, Murphy Oil Corporation, Pertamina, Petrobras, Petronas, Repsol, Shell, Total

GeoIsotopes has a long and successful track record since its introduction in 2011:
>280 wells >40 clients

Jobs completed in
>20 countries across 5 continents

Onshore and Offshore:
Conventional and Unconventional

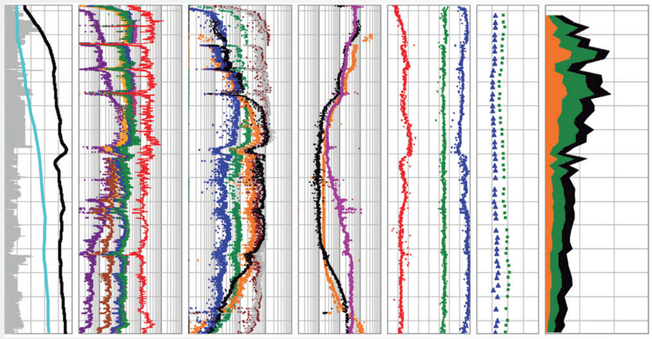
Sample application of GeoIsotopes data

GEOIsotopes

Published Technical Papers

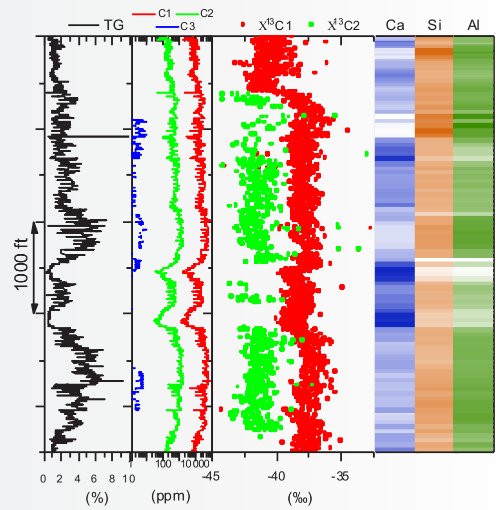
Innovative advanced mudlogging technologies for fluid characterization of Al Shaheen oil field *Reservoir Management in Carbonates (EAGE WIPIC 2019)*

Carbon isotopes of C_1 and C_3 can be used as biodegradation proxies. This case study puts the bases for building an API model by including a series of molecular parameters, amongst which carbon isotopes of C_1-C_3, enabling observation of oil quality variations along the well bore.



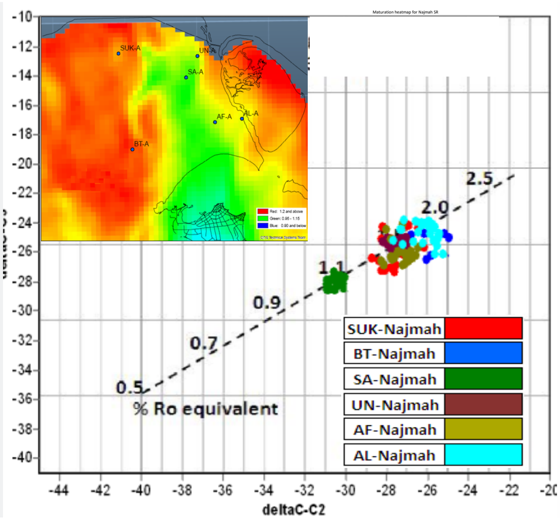
Cost-Effective Reservoir Characterization from Advanced Surface Logging Technologies in Unconventional Reservoirs *(URTEC 2016)*

Realtime carbon isotopes of C_1 and C_2 help to identify formation boundaries, potential faults or localized barriers and compartments and comply other information to evaluate the vertical and lateral formation heterogeneity. They are good indicators of gas maturity which helps to project production fluid typing.



Mud gas isotope logging while drilling, the benefits of analyzing C_2 and C_3 at wellsite *(EAGE 2018)*

Extension of carbon isotopic analysis to C_2 and C_3 allows the study of apparent gas maturity in reservoir even when there is a biogenic contribution to methane. In this study the isotopic signature of C_1-C_3 has been screened in the same formation across the same field for 6 wells resulting in a correlation between apparent gas maturity and source rock maturity maps.



Guaranteeing delivery of consistently high level, high quality services worldwide

There are multiple professional contributors involved in the delivery of advanced services to the customer, each with specific duties and responsibilities.

1

GAS SPECIALIST

runs the service at wellsite, has received common, standardized training at Milan headquarters

2

DOMAIN EXPERT

checks data quality for all instruments deployed worldwide, ensuring consistency of service delivery

3

QUALITY ASSURANCE MANAGER

guarantee highest quality and worldwide coordination

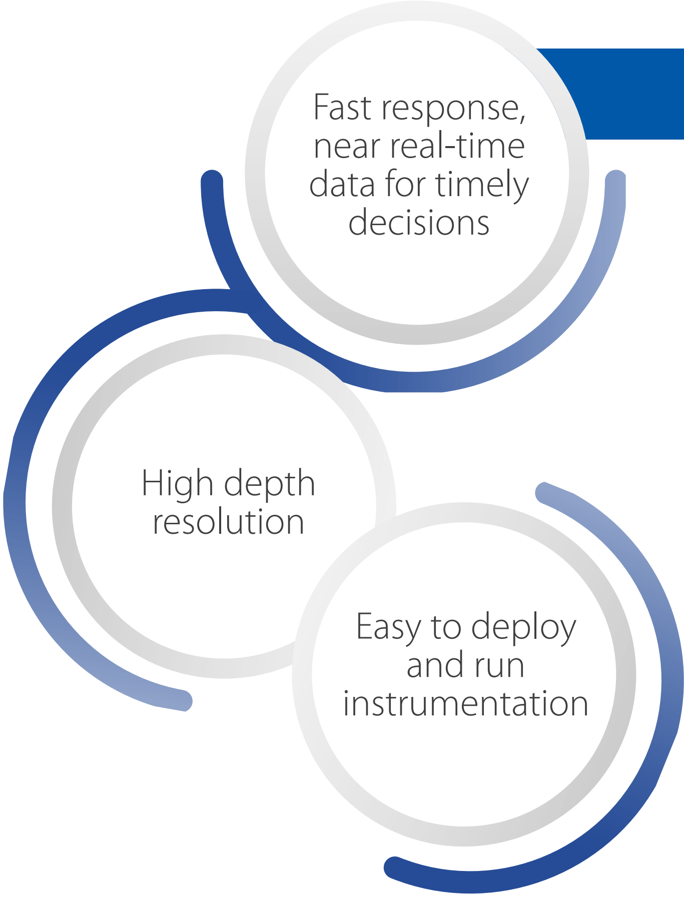
TOWARDS OPTIMUM SERVICE QUALITY:
Regular quality checks of GeoIsotopes data are performed by collecting gas samples in GeoTubes and analyzing them using GC-IRMS equipment situated in GEOLOG's GeoTech laboratories around the world.

Sampling on rigsite

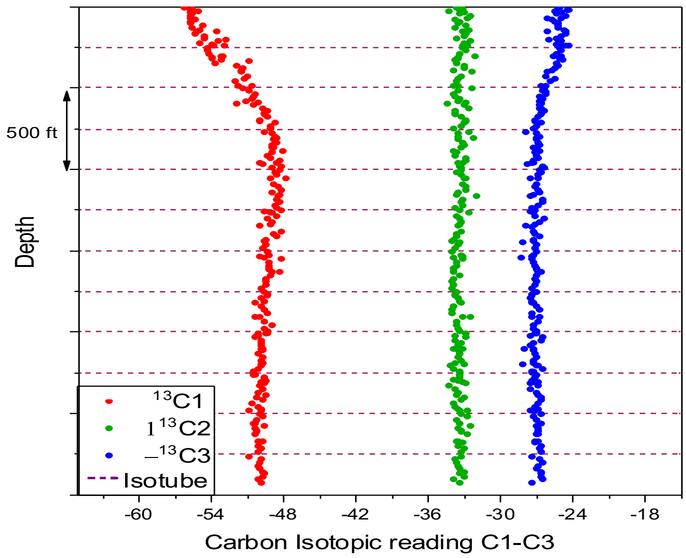

Analysis in GeoTECH laboratory

GeoIsotopes is a tool for timely decisions. It provides a high resolution description of carbon isotopes behavior along wellbore with a comparable quality to laboratory results but without the need of shipping samples and waiting for results.

Different Approaches: wellsite and laboratory



$\delta^{13}C_1$ and $\delta^{13}C_2$ in 3 minutes
$\delta^{13}C_1$, $\delta^{13}C_2$ and $\delta^{13}C_3$ in 8 minutes



Data collected at wellsite using the CRDS system, compared to an Isotube sampling program (dotted lines).

Wellsite Requirements

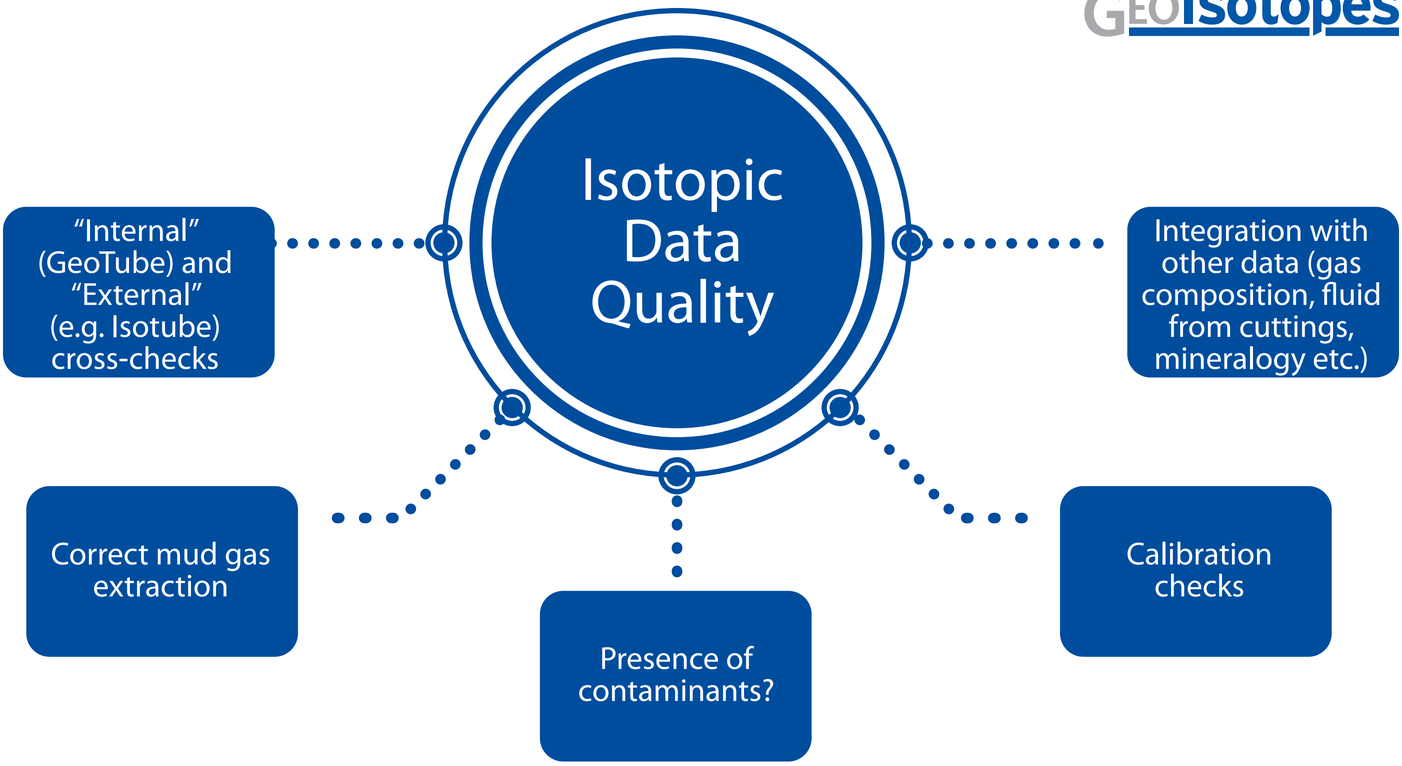
· **Robustness:** in terms of both mechanical stress resilience and application:
The instrument and method setup must be fundamentally operator-independent.
To avoid data loss, the instrument must function on a continuous 24/7 basis over multiple days without operator intervention

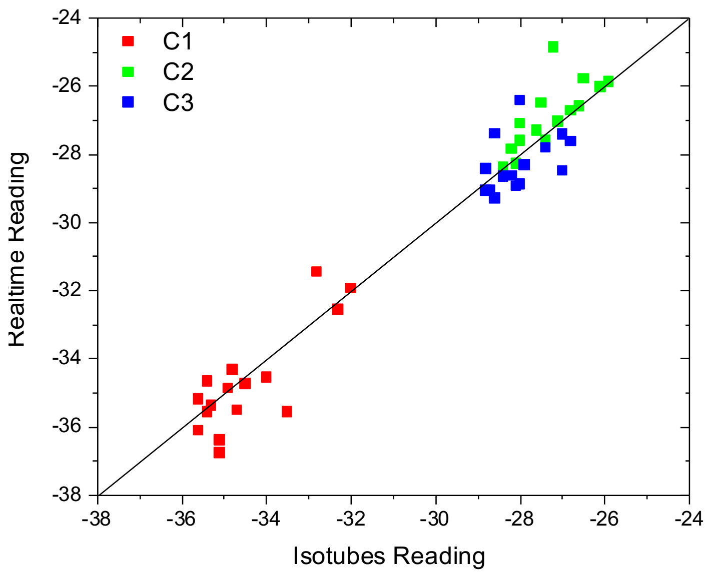
· **Self diagnostics:** automatic detection of residual methane after oxidator for self diagnosis and fast intervention

· **Wide dynamic range**: fine tuning of sample dilution is not possible at wellsite, where only an approximate estimation of concentration is available

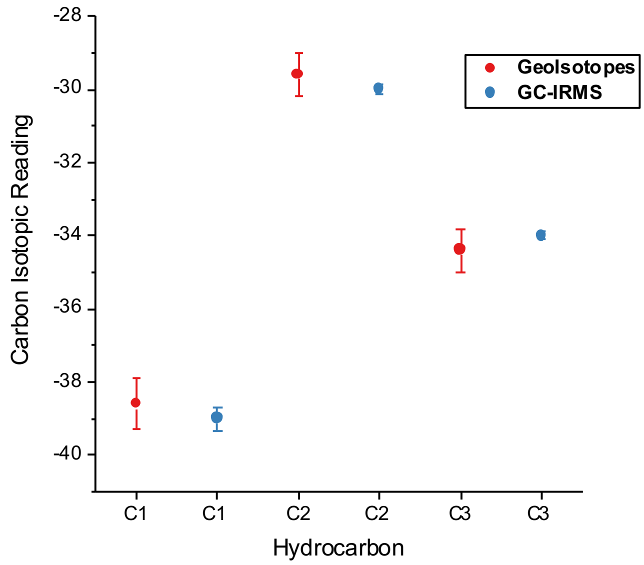
· **Calibration stability**: low drift of calibration over time so as to reduce operator intervention and avoid instrument downtime while logging

· **Long life oxidator:** frequent catalyst regeneration and re-activation may be acceptable in a laboratory instrument, not viable in a field deployed solution





Comparison of accuracy between wellsite readings (GeoIsotopes) and laboratory results (from Isotubes)



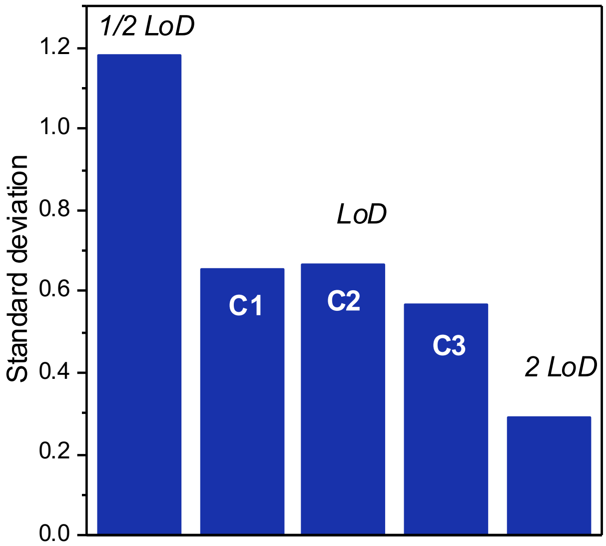
Comparison of performance in terms of repeatability: 10 analyses with values of GC-IRMS (blue) and GeoIsotopes (red). Gas sample is a mixture of C_1-C_3 at a concentration of 5000 ppm

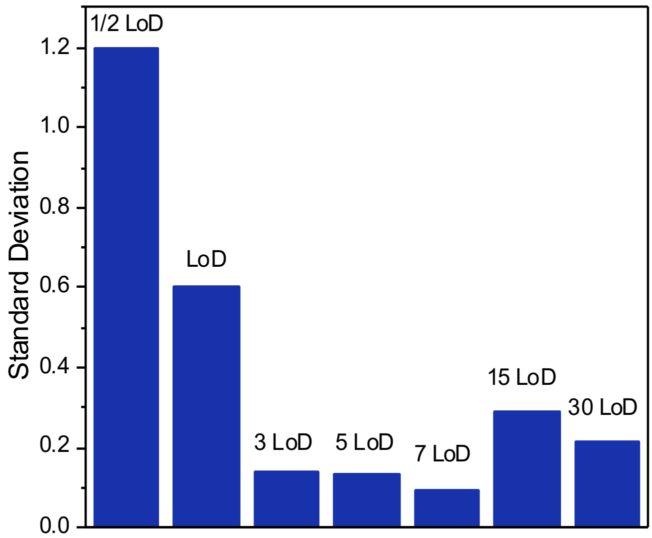
GeoIsotopes Technical Specifications

Working principle	GC-ox-CRDS (Cavity Ring-Down Spectroscopy)
Analytes	$\delta^{13}C_1$, $\delta^{13}C_2$, $\delta^{13}C_3$
Limit of Detection (LoD)	1000 ppm for C_1, 500 ppm for C_2 and C_3
Turnaround Time	3 min for C_1 and C_2, 8 min for C_1, C_2 and C_3

GeoIsotopes is in-house developed and covered by patents MI2011A001647 (Italy) and US2013064715 (USA)

Technical Performance at LoD





GC-ox-CRDS performances close to the LoD for C_1-C_3 (left);
repeatability vs concentration of C_1 (right). Repeatability is expressed as standard deviation on 10 measurements for both plots.

Alkene Contamination

Alkenes may be present in mud gas as artefacts arising from the action of the drill bit on oil contained in drilling fluids: they must also be removed from the gas sample to avoid impacting isotopic measurements. In the laboratory, chromatography physically separates any alkenes present from the alkanes before analysis. For wellsite application, Geolog has developed KLENE: a tool installed ahead of the GeoIsotopes, which chemically removes alkenes whilst avoiding fractionation or scattering effects on the isotopic readings (Table below).

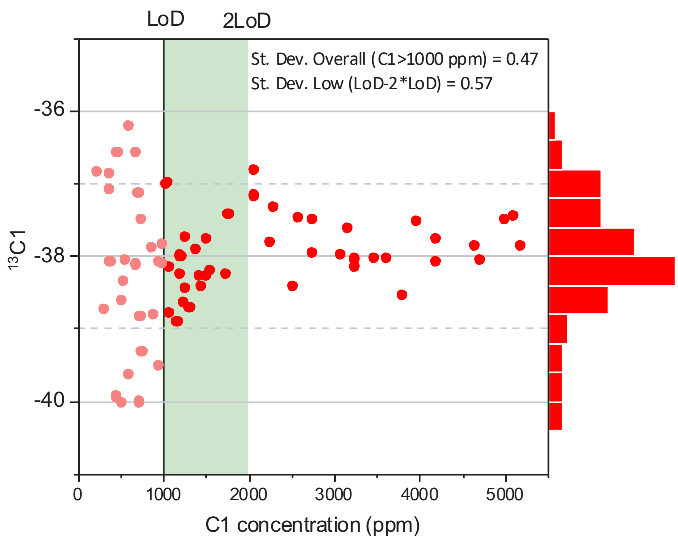
KLENE	Composition	Average $\delta^{13}C_1$ (‰)	Offset (‰)*	St. Dev. (‰)
Off	C_1, ethene, propene	-38.8	-	0.42
On	C_1, ethene, propene	-38.9	-0.1	0.38
Off	C_1, ethene, propene	-39.1	-0.2	0.40

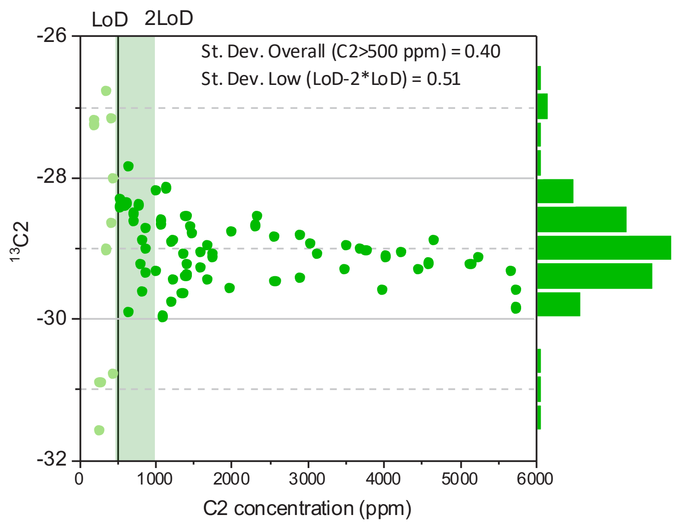
Table: Repeatability and accuracy test on C_1 when KLENE is installed and removing alkenes
(standard deviation calculated on 10 consecutive analyses with or without the removal active)

**the used gas mixture is not an isotopic certified standard, thus accuracy shifts have been evaluated as offsetting the average values for each batch to the previous one.*

Technical performances: precision and accuracy vs concentration

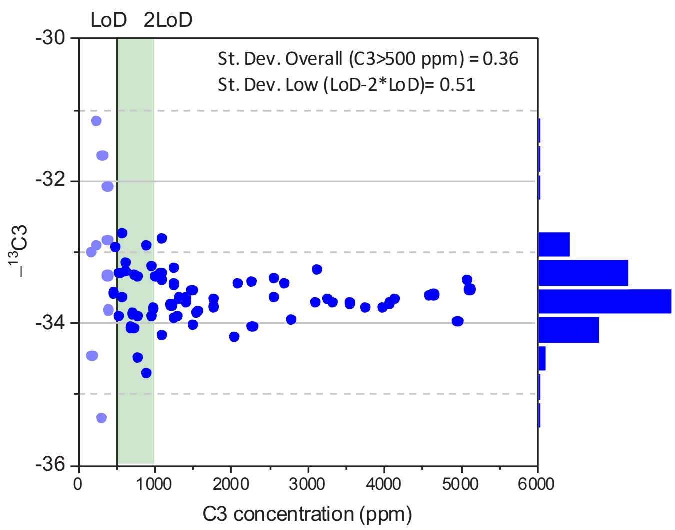
The graphs below show tests done at different dilutions of a single test-gas bottle (starting concentration of ≈ 5000 ppm for all gases) with the purpose of studying repeatability vs concentration. The resulting standard deviations are matching with the technical specification: when approaching the LoD , repeatability is a critical parameter.





Standard deviations for each component have been calculated for all the readings above the LoD (St. Dev. Overall), while St. Dev. Low, indicated by the light green area in the plots, is calculated for all points in the interval between LoD and two times LoD (2LoD).

Isotopic composition is an intrinsic characteristic of any hydrocarbon: its value should therefore be unrelated to concentration. The absence of any trend in the data above: reading vs concentration, confirms that the two parameters are independent and that isotopic values measured are not correlated to gas concentration.



More details on technical specifications and comparison between IRMS and CRDS techniques: "Carbon isotopes from mud gas: lab IRMS or wellsite laser-assisted technologies?" (IMOG 2019)