Schlumberger

Ocean Software Development Framework

Extend your workflow in the Petrel platform for Petrel reservoir and production engineering

BENEFITS AND FEATURES

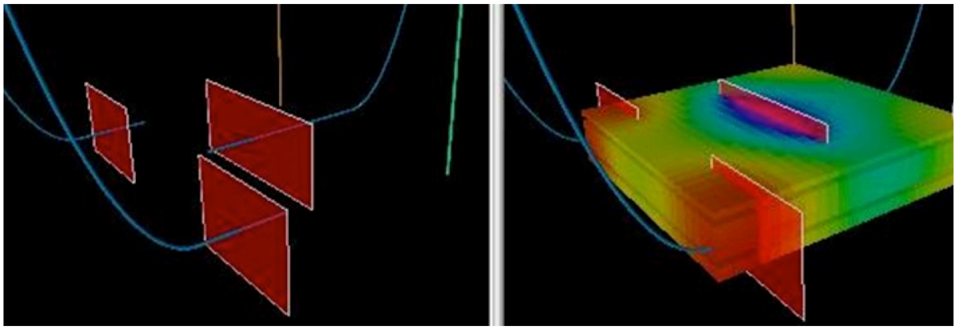
- Create time saving plug-ins for simple data manipulation
- Automate repeatable workflows to enhance productivity for new users and experts
- Create guided workflows to lessen the learning curve for new users
- Enables reservoir engineering analysis and data analytics
- Integrates and enhances data processing from geology to gridding, reservoir simulation, and production evaluation
- Supports both conventional and unconventional shale studies
- Allows optimization and uncertainties studies for history matching, volumetric calculation, field development planning
- Provides results analysis and charting windows for reservoir quality control and data validation
- Enables custom simulation in Petrel workflows

The Petrel* E&P software platform enables reservoir engineers to collaborate effortlessly with each other as well as with geoscience and production specialists. The Ocean* software development framework's application programming interface (API) unlocks elements of the reservoir engineering and production engineering modules to enable developers to extend its capabilities with new features. Company developers can concentrate on extending primary functionality while independent developers can provide additional components in the form of plug-ins. Plugins can vary in their complexity, from a simple time-saving algorithm that automates a manual data-manipulation process that can be created in minutes by someone with basic programming skills to plug-ins that provide more complex capabilities, such as a custom simulator that will require greater commitment by a team of programmers and oilfield experts.

Below is a small sample of Ocean framework APIs that are available to create various plug-ins that support reservoir engineers and petroleum engineers in their everyday work.

Fluid

Professionals involved in petroleum exploration and production have varying reasons for analyzing and describing the hydrocarbon fluids and water found together in petroleum reservoirs. The fluid API plays an important role in many petroleum disciplines' plug-ins. For reservoir engineers, one of the key uses of this data is in reservoir simulation. For production engineers, one of the key uses is in well completion design. The Ocean framework enables you to programmatically create a black-oil fluid model and a compositional fluid model. The Ocean framework's fluid API can be used in many different types of plug-in workflows, such as guided workflow plug-ins, plug-ins that check the quality of the fluid data, or plug-ins that help you to model hydraulic fracturing for a large field with many wells.



EasyFrac plug-in developed by Schlumberger, available in the Ocean store.

Rock physics

One of the objectives in modeling rock mechanics for a reservoir simulation is to understand the interaction between fluids and the reservoir rock. There are a number of functions of saturation, or pressure used in simulation that represent the physics of fluids and the rock. The Ocean framework APIs enable you to programmatically create saturation, compaction, and adsorption functions.

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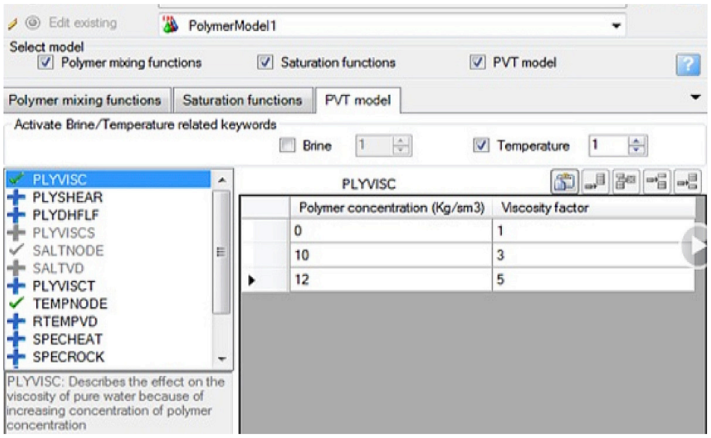


Edit existing: PolymerModel1

Select model
☑ Polymer mixing functions ☑ Saturation functions ☑ PVT model

Activate Brine/Temperature related keywords
□ Brine 1 ☑ Temperature 1

PLYVISC

Polymer concentration (Kg/sm3)	Viscosity factor
0	1
10	3
12	5

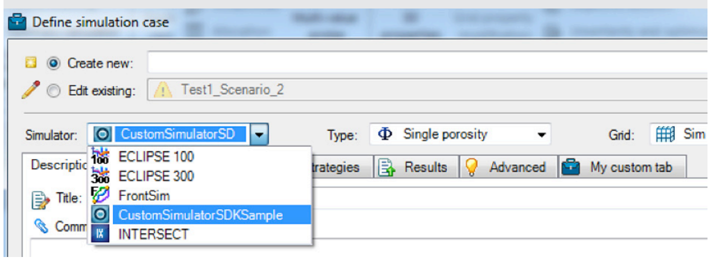
PLYVISC: Describes the effect on the viscosity of pure water because of increasing concentration of polymer concentration

Phoenix plug-in developed by Schlumberger, available in the Ocean store.

The Ocean framework's rock physics API will enable you to create plug-ins that can extend the Petrel platform to support various methods of simulation such as enhanced oil recovery (EOR).

Custom simulators

The EclipseFormatSimulator API assists in adding a specific simulator to enable your custom workflow, or bring your full-field simulator to the Petrel platform. Once your simulator supports input/output in the ECLIPSE* industry-reference reservoir simulator 100/300 format, it can be seamlessly plugged into the Petrel platform to run from the plug-in, or in the Define Simulation Case process and results will be automatically imported to the Petrel results pane. Custom cases and tabs are also available to fully support your simulator's functionality within the Petrel platform.



Define simulation case

● Create new:
○ Edit existing: Test1_Scenario_2

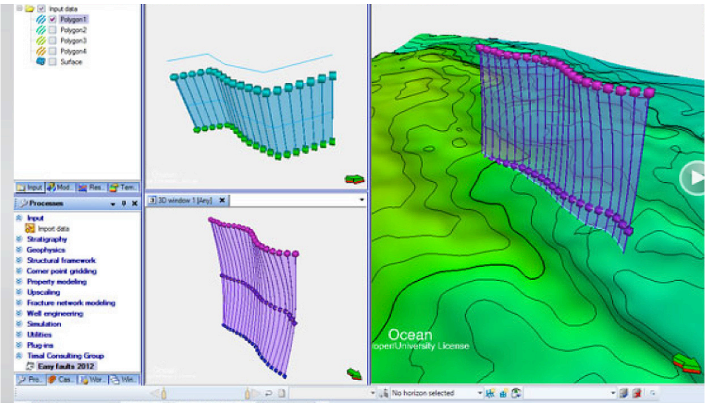
Simulator: CustomSimulatorSD Type: Single porosity Grid: Sim

CustomSimulator sample from Ocean framework.

Grids

The aim of gridding in reservoir simulation is to turn the geological model of the field into a discrete system on which the fluid flow equations can be solved. The Petrel platform's reservoir model representation is the pillar grid. The construction of pillar grid reservoir models is facilitated by the processes in the interactive grid construction in the Petrel platform (i.e., the processes in the structural modeling process folder).

The Ocean framework API enables the creation and manipulation of grids. The cell property representations offer full manipulation through the API (i.e., to create, read, update, and delete). Access to local grid refinement and stair-step modeling is also supported. The PillarFault API enables modeling of reservoirs that contain faults.

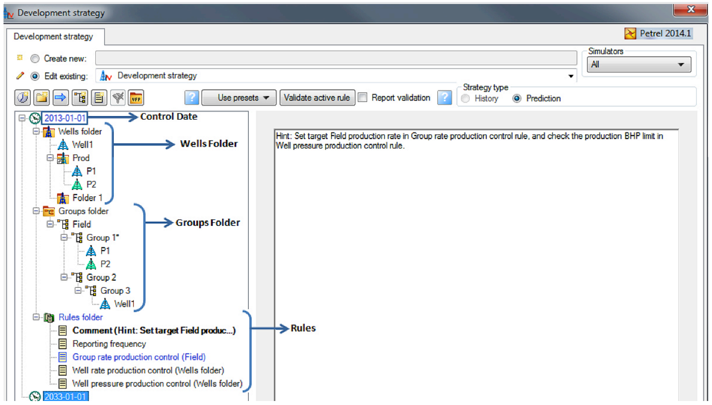


Easy Faults plug-in developed by Timal Consulting Group, available in the Ocean store.

Creating a reservoir simulation grid can be a complicated and time-consuming task. With the Ocean framework's PillarGrid API, you can create plug-ins that can help the reservoir engineer with grid creation and manipulation, or you can create a plug-in that can perform quality control (QC) of the grid data to ensure that it is ready for simulation.

Development strategy

The development strategies facility is used to tell a simulator how a field will be developed, which wells will produce, or inject, what the pressure



Development strategy

Petrel 2014.1

○ Create new:
● Edit existing: Development strategy

Simulators: All

Use presets | Validate active rule | □ Report validation

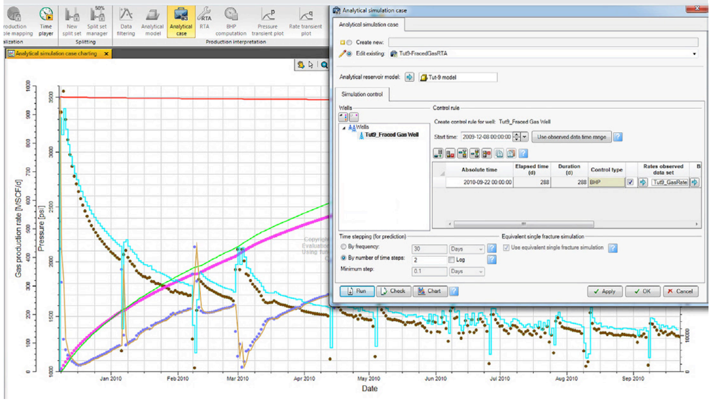
Strategy type: ○ History ● Prediction

Hint: Set target Field production rate in Group rate production control rule, and check the production BHP limit in Well pressure production control rule.

DevelopmentStrategies structure, available through Ocean API rate controls and limits are, what operations will be carried out on the wells over time, etc. Whether you run an industry-standard simulator such as the ECLIPSE simulator (100/300), or a custom simulator, an essential part of the simulation setup is to specify development strategies. Ocean supports a full scale of standard development strategy rules, both for history and prediction, and enables custom rules. An existing development strategy domain object provides limited functionality to access development strategy collection, create/delete strategy, and limited read access to name and description. The 2014 release overcomes this with the development strategies namespace which has been introduced to provide types to create, read, and edit development strategy, and work with the control date, wells, groups, and rules folders.

Results and charting

The visualization and charting functionality facilitates presentation and QC of simulation results, which is an important step for many workflows. The Ocean framework APIs allow presentation of simulation case results on virtually any suitable window (2D, 3D, function window, charting, map, and other types). One method of presentation is facilitated by the ToggleWindow simulation case results facility created by the simulator, or constructed using the results provider API. Another method of presenting results is to use the study and chart objects used in the results charting and analysis facility. Either method gives the plug-in developer the flexibility of charting and presenting various intermediate, summary, or final simulation results.



Analytical simulation case

Analytical simulation case

○ Create new:
● Edit existing: Tut9-FracedGasRTA

Analytical reservoir model: Tut-9 model

Simulation control

Wells

Wells
Tut9_Fraced Gas Well

Control rule

Create control rule for well: Tut9_Fraced Gas Well

Start time: 2009-12-08 00:00:00 [Use observed data time range]

Absolute time	Elapsed time (d)	Duration (d)	Control type		Rates observed data set
2010-09-22 00:00:00	288	288	BHP	☑	Tut9_GasRate

Time stepping (for prediction)

○ By frequency: 30 Days
● By number of time steps: 2 □ Log
Minimum step: 0.1 Days

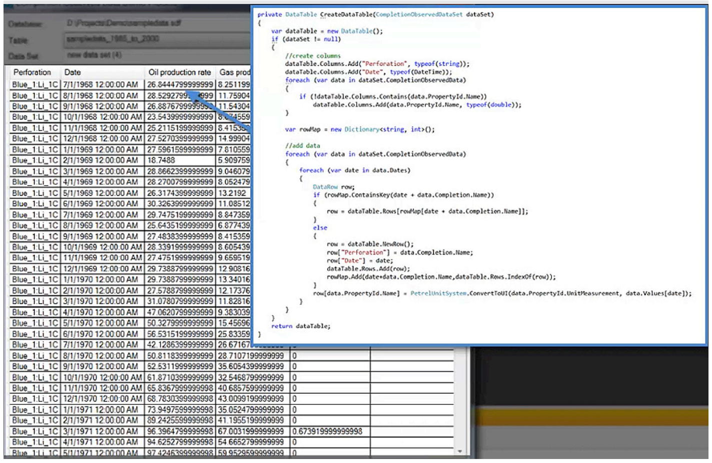
Equivalent single fracture simulation

☑ Use equivalent single fracture simulation

Production interpretation module uses chart and study objects to show results.

Completion-level observed data

Production monitoring and surveillance is a key function in the production engineering module. Completion-level data can help you to evaluate inflow and outflow performance at any depth range that has a flow rate associated with it between reservoir and wellbore. You can evaluate the intervals that are not performing and make decisions for remedial action. The import of completion-level data is currently done with the OFM* well and reservoir analysis software data connector, or through the split manager and use of split sets. With the completion-level observed data API you can write a plug-in to automate the import of data from third-party vendors to create completion level observed data sets. The data sources can be from Microsoft Excel, Oracle, or SQL servers. Once production history is in the Petrel platform, as a completion level observed dataset, it can be used in the well section window to display production alongside completion and log data in a preconfigured production track, as well as used in the production bubble mapping and production mapping processes.



Database: D:\Projects\Demo\sampledata.sdf
Table: sampledata_1985_to_2000
Data Set: new data set (4)

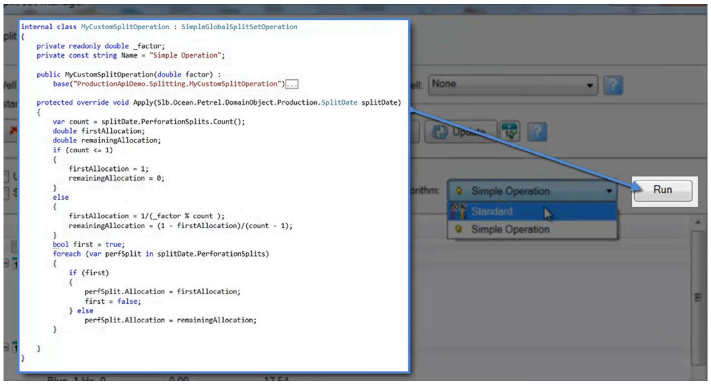
Perforation	Date	Oil production rate	Gas prod	
Blue_1:Li_1C	7/1/1968 12:00:00 AM	26.8444799999999	8.251199	
Blue_1:Li_1C	8/1/1968 12:00:00 AM	28.5292799999999	11.75904	
Blue_1:Li_1C	9/1/1968 12:00:00 AM	26.8876799999999	11.54304	
Blue_1:Li_1C	10/1/1968 12:00:00 AM	23.5439999999999	8.074559	
Blue_1:Li_1C	11/1/1968 12:00:00 AM	25.2115199999999	8.41535	
Blue_1:Li_1C	12/1/1968 12:00:00 AM	27.5270399999999	14.99904	
Blue_1:Li_1C	1/1/1969 12:00:00 AM	27.5961599999999	7.810559	
Blue_1:Li_1C	2/1/1969 12:00:00 AM	18.7488	5.909759	
Blue_1:Li_1C	3/1/1969 12:00:00 AM	28.8662399999999	9.046079	
Blue_1:Li_1C	4/1/1969 12:00:00 AM	28.2700799999999	8.052479	
Blue_1:Li_1C	5/1/1969 12:00:00 AM	26.3174399999999	13.2192	
Blue_1:Li_1C	6/1/1969 12:00:00 AM	30.3263999999999	11.08512	
Blue_1:Li_1C	7/1/1969 12:00:00 AM	29.7475199999999	8.847359	
Blue_1:Li_1C	8/1/1969 12:00:00 AM	25.6435199999999	6.877439	
Blue_1:Li_1C	9/1/1969 12:00:00 AM	27.4838399999999	8.415359	
Blue_1:Li_1C	10/1/1969 12:00:00 AM	28.3391999999999	8.605439	
Blue_1:Li_1C	11/1/1969 12:00:00 AM	27.4751999999999	9.659519	
Blue_1:Li_1C	12/1/1969 12:00:00 AM	29.7388799999999	12.90816	
Blue_1:Li_1C	1/1/1970 12:00:00 AM	29.7388799999999	13.34016	
Blue_1:Li_1C	2/1/1970 12:00:00 AM	27.5788799999999	12.17376	
Blue_1:Li_1C	3/1/1970 12:00:00 AM	31.0780799999999	11.82816	
Blue_1:Li_1C	4/1/1970 12:00:00 AM	47.0620799999999	9.383039	
Blue_1:Li_1C	5/1/1970 12:00:00 AM	50.3279999999999	15.45696	
Blue_1:Li_1C	6/1/1970 12:00:00 AM	56.5315199999999	25.83359	
Blue_1:Li_1C	7/1/1970 12:00:00 AM	42.1286399999999	26.67167	
Blue_1:Li_1C	8/1/1970 12:00:00 AM	50.8118399999999	28.7107199999999	0
Blue_1:Li_1C	9/1/1970 12:00:00 AM	52.5311999999999	35.6054399999999	0
Blue_1:Li_1C	10/1/1970 12:00:00 AM	61.8710399999999	32.5468799999999	0
Blue_1:Li_1C	11/1/1970 12:00:00 AM	65.8367999999998	40.6857599999999	0
Blue_1:Li_1C	12/1/1970 12:00:00 AM	68.7830399999998	43.0099199999999	0
Blue_1:Li_1C	1/1/1971 12:00:00 AM	73.9497599999998	35.0524799999999	0
Blue_1:Li_1C	2/1/1971 12:00:00 AM	89.2425599999998	41.1955199999999	0
Blue_1:Li_1C	3/1/1971 12:00:00 AM	96.3964799999998	67.0031999999999	0.673919999999998
Blue_1:Li_1C	4/1/1971 12:00:00 AM	94.6252799999998	54.6652799999999	0
Blue_1:Li_1C	5/1/1971 12:00:00 AM	97.4246399999998	59.9529599999999	0

```
private DataTable CreateDataTable(CompletionObservedDataSet dataSet)
{
    var dataTable = new DataTable();
    if (dataSet != null)
    {
        //create columns
        dataTable.Columns.Add("Perforation", typeof(string));
        dataTable.Columns.Add("Date", typeof(DateTime));
        foreach (var data in dataSet.CompletionObservedData)
        {
            if (!dataTable.Columns.Contains(data.PropertyId.Name))
                dataTable.Columns.Add(data.PropertyId.Name, typeof(double));
        }

        var rowMap = new Dictionary<string, int>();

        //add data
        foreach (var data in dataSet.CompletionObservedData)
        {
            foreach (var date in data.Dates)
            {
                DataRow row;
                if (rowMap.ContainsKey(date + data.Completion.Name))
                {
                    row = dataTable.Rows[rowMap[date + data.Completion.Name]];
                }
                else
                {
                    row = dataTable.NewRow();
                    row["Perforation"] = data.Completion.Name;
                    row["Date"] = date;
                    dataTable.Rows.Add(row);
                    rowMap.Add(date+data.Completion.Name,dataTable.Rows.IndexOf(row));
                }
                row[data.PropertyId.Name] = PetrelUnitSystem.ConvertToUI(data.PropertyId.UnitMeasurement, data.Values[date]);
            }
        }
    }
    return dataTable;
}
```

Sample code to read the completion level observed data.

Split sets

Split sets are used to back-allocate wellbore production by splitting well-level observed data into completion intervals. The Ocean



```
internal class MyCustomSplitOperation : SimpleGlobalSplitSetOperation
{
    private readonly double _factor;
    private const string Name = "Simple Operation";

    public MyCustomSplitOperation(double factor) :
        base("ProductionApiDemo.Splitting.MyCustomSplitOperation")...

    protected override void Apply(Slb.Ocean.Petrel.DomainObject.Production.SplitDate splitDate)
    {
        var count = splitDate.PerforationSplits.Count();
        double firstAllocation;
        double remainingAllocation;
        if (count <= 1)
        {
            firstAllocation = 1;
            remainingAllocation = 0;
        }
        else
        {
            firstAllocation = 1/(_factor % count );
            remainingAllocation = (1 - firstAllocation)/(count - 1);
        }
        bool first = true;
        foreach (var perfSplit in splitDate.PerforationSplits)
        {
            if (first)
            {
                perfSplit.Allocation = firstAllocation;
                first = false;
            } else
                perfSplit.Allocation = remainingAllocation;
        }

    }
}
```

Well: None

Algorithm: Simple Operation

Sample code to perform the splitting operation.

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framework API for split sets allows you to create, edit, and delete splits sets in a Petrel platform project. This will enable you to create a plug-in that imports zonal allocations from an external data source and create split sets with wells, perforations, and factors based on the imported data. This split set can then be applied to the well-level observed data, which will generate a completion-level dataset that can then be used with the production analytics function, such as the well section window production track, production bubble mapping, and production mapping processes.

The split set manager offers an even allocation as the default algorithm. With the Ocean framework API, you can create custom splitting algorithms that end users can access through the algorithm list in the split manager interface. Algorithms such as:

$$\frac{\phi h}{\mu}\ \phi h,\ kh,$$

and h can be programmed into the split manager with this API.

Developer resources

There are numerous developer resources available for the Petrel platform plug-in developer on the Ocean framework.

Ocean software development kit (framework)

When you install the Ocean framework, you will have access to the following documents:

OceanPetrel:
This is the main help file to assist Ocean framework developers to search various APIs on domain objects.

Petrel UI Guide:
This guide defines the Petrel platform user experience through a set of look-and-feel rules for Ocean developers to follow to ensure consistency with the Petrel platform.

Sample code:
Sample code that demonstrates how to use the API for a number of domain objects. For example, custom domain objects, custom simulators, and SeismicAttributes, among others.

Wizards:
Wizard applications that can enable the Ocean framework developer to get started on their plug-in quickly. There are nine wizards that are included with the Ocean Framework.

Visual studio tools

In the visual studio environment there are a number of tools available to the Ocean framework developers.

Ocean search page:
To search for webinars, how-to videos, and sample code.

Project upgrade tool:
To help upgrade projects to the latest release.

Ocean quality assistant:
To help with testing of your plug-in.

Ocean start page:
Easy access to search, find out what's new, how-to videos, and tools.

Help

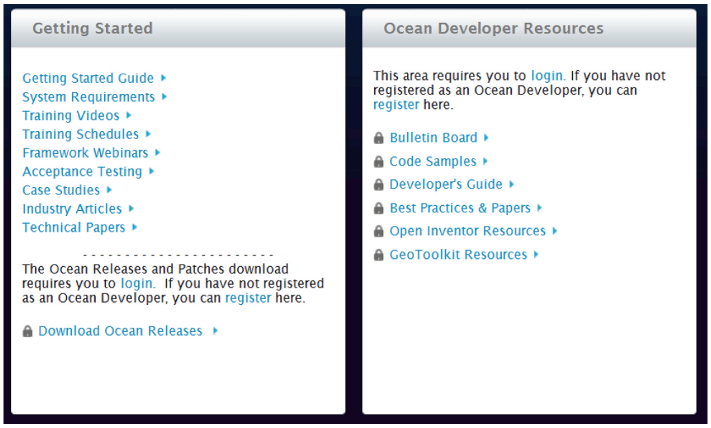
Ocean support:
This is where you can submit your questions and issues.

Ocean forum:
This is where you can ask other developers questions.

Ocean Store

There is a wealth of information and resources available to the Ocean developer in the Ocean Store—such as the "getting started" section, where you can find information about training, webinars, and case studies—to name a few. In the Ocean developer resources section you can find a developer's guide that covers many subjects relating to plug-in development.

The resources mentioned are just a small sample of what is available. For details on all the resources, please visit the Ocean Store.



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There are numerous developer resources available

E-mail sisinfo@slb.com or contact your local Schlumberger representative to learn more

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