IHS Markit®

Permian Basin Kingdom Project

The Permian Basin Kingdom Project contains 3D geological model of over 60 formations from the Basement to the Upper Permian, all built from IHS Markit interpreted tops. The project contains cleaned Wells, Interpreted Tops, Digital Logs and Allocated Production raw data.

It also contains various types of analytical data, including Zones Attributes, and Grid files, as well as the results of an analysis of 52 plays, comprising 11 Shale (Continuous Type) and 41 Stratigraphic-Structural (Non-Continuous Type) which incorporates Producing Formation from Interpreted Tops (PRODFit), a new enhancement to the IHS Well database.

The objective of the project is to provide a basic ready-made geological platform and raw data for any further work on any area of interest within the basin where users can readily incorporate their proprietary and third-party data. This would save users hundreds of man hours required for data mining, population and collation.

The boundary of the project follows classification and limit in the IHS Markit basin database. No seismic data was used in the project and no structural interpretation and mapping was performed.

File sizes
86 GB Total

Kingdom project Directory
(Shape files, grids, models etc.)
36 GB

Kingdom project
SQL database
50 GB

Projection System

NAD_1927_UTM_Zone_14N, Linear Unit: Foot_US

Software Requirement

- Kingdom Geology package (VuPAK and EarthPAK modules)
- SQL Server

Data Inventory and Description

Authors

Kingdom Authorship allows for enhanced data management in Kingdom Projects. Each project user can create their own unique authorship, allowing them to keep track of,and manage their own interpretation.

Admin: The Admin author is created as the default author in Kingdom. In order to avoid listing out volumes of data in the general Kingdom Project Folder, this author is only used for management purposes. Subsequent authors have been created to store various types of data. Ideally, each user accessing the project, will create their own authorship for their specific interpretation.

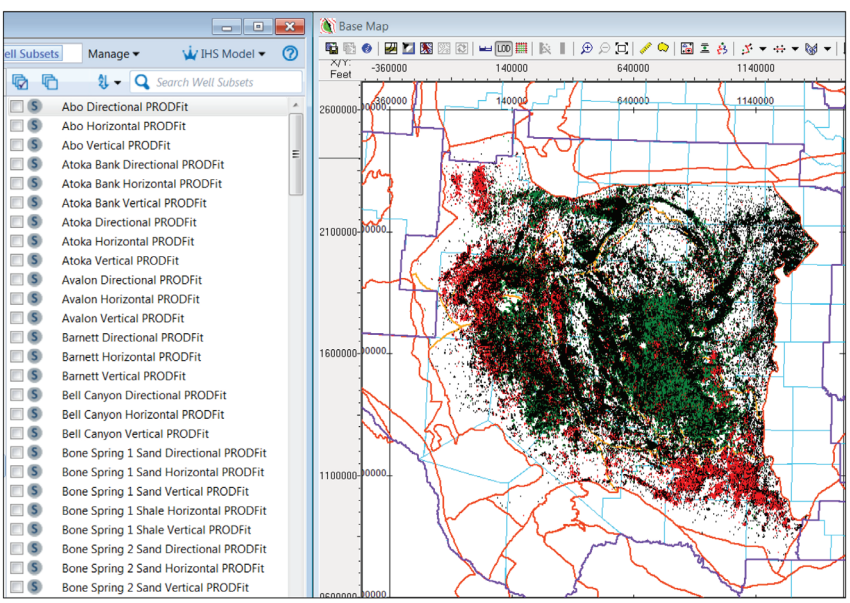
IHSM Interpreted: This author is available for the sole purpose of populating the project with IHS Markit Interpreted Tops for the entire Permian Basin. It separates them from any other formation tops that are loaded from additional sources.

IHSM Model: This author is where all of the modeling work for the entire Permian Basin is stored.

Midland Benches: This author houses IHS Markit Interpreted Formation Benches in the Midland Basin. Modeling on these Benches is also available from this authorship.

Delaware Benches: This author houses IHS Markit Interpreted Formation Benches in the Delaware Basin. Modeling on these Benches is also available from this authorship.

*All users are advised to create a separate Author for any further work.



Permian Basin Well Data

Well Data

Total number of wells from IHSM Well database

467,468

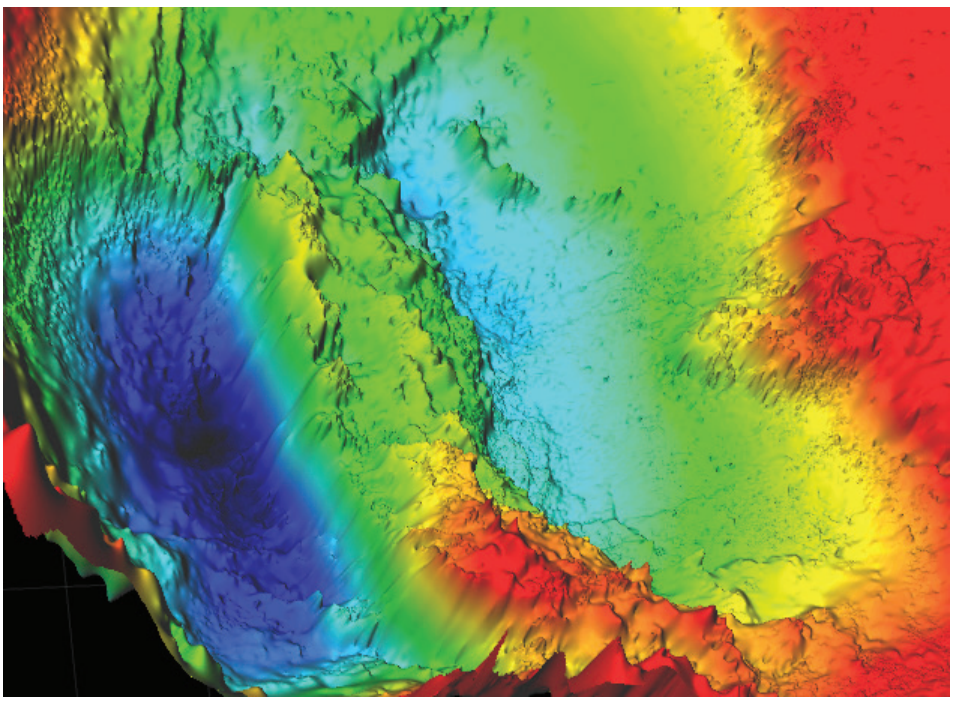
Total number of wells with IHSM Production volumes

326,717

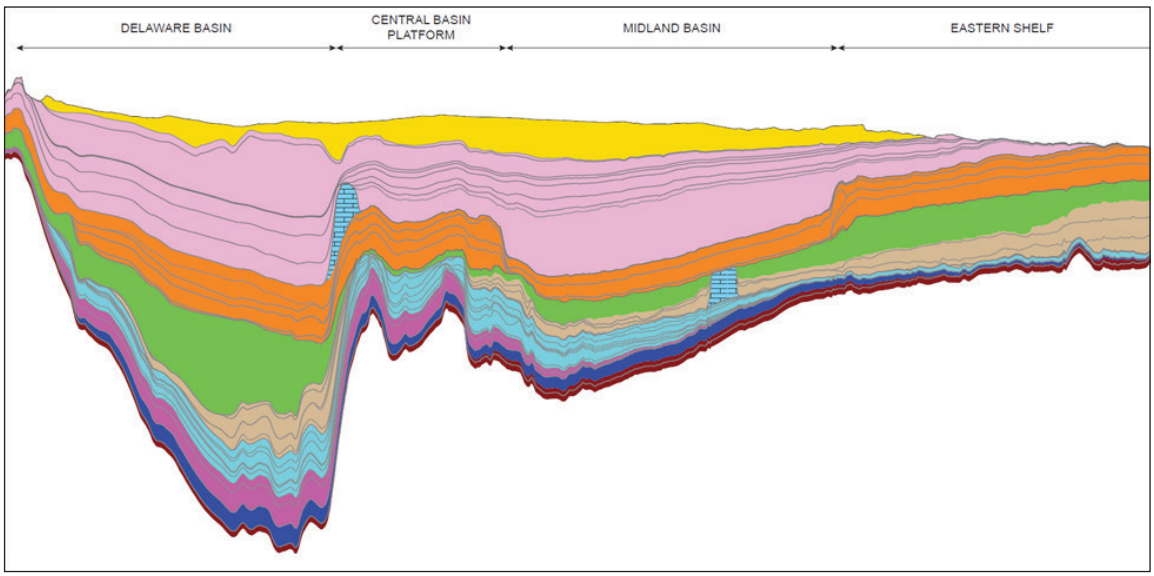
Wells with Interpreted Formation Tops

235,091

all tops used are IHSM tops.
Top depths are in feet.



3D Structure Map

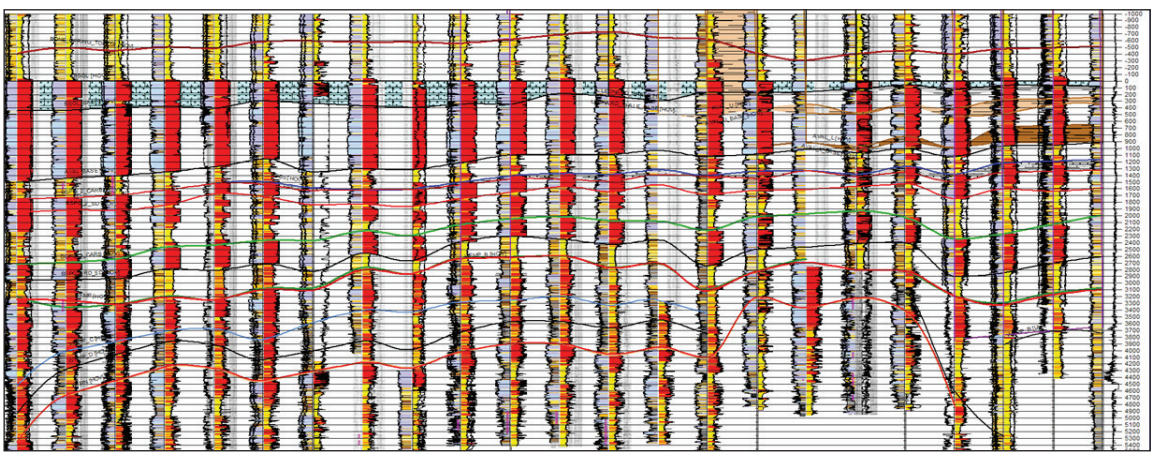


Permian Basin cross-section using IHSM interpreted formation tops

Digital Logs

Total number of Wells with digital Logs

44,493



Selected Benches Correlated Tops

Borehole Zone Data

A zone corresponds to the interval of a formation defined by the top of the formation in question to the top of the underlying formation. Zone data contains following attributes:

PRODFit contains the following enhanced attributes:

- **Producing Formation(s)**
- **IP Tests**
- **Perforation Intervals**
- **HZ Producing Formation (Landing Zone)**
- **Core and Drill Stem Tests**
- **Pressure Tests**
- **Well Tubulars**
- **Mud Weights**

Borehole type contains the following hole direction attributes:

- **Vertical**
- **Directional**
- **Horizontal**

Grid Data

Total Number of Grid files

232

163 under "IHS Model" author, **60** under "Delaware Benches" author and **20** under "Midland Benches" author. All the Grids are 1,000 feet cell/pixel sized and prepared with flex-gridding method.

Top Grid Files

76

prepared by gridding IHS Markit Interpreted Tops. Each grid is a continuous plain across the basin passing through formations/benches tops, where the formations/benches may not be necessarily time equivalent but adjacent horizontally or vertically. The entire section is built by stacking TVTs to avoid cross-over and gaps. The top grids are numbered based on their stratigraphic position from top to the bottom.

TVT Grid Files

73

prepared by gridding TVT attributes values from zones depicting the distribution of vertical thickness of a formation/bench.

GR_ARTH Mean

74

prepared by gridding GR_ARTH Mean attributes value from zones providing a quick view of muddy and non-muddy parts of the formations/benches. Value less than 5 and above 300 are considered anomalous and ignored during the gridding.

Ro_Avg

9

for the all the source rock formations, prepared by gridding Ro values derived from Oil Gravity API or in combination with Ro_Avg from published literatures.

Literature

Following documents are available in the folder "The Permian Basin\Literature"

1. **IHS Markit Permian Basin Kingdom Project Brochure**
2. **Stratigraphic Chart**
3. **SW-NE Geological Section**
4. **IHSM Delaware Benches Type Log**
5. **Permian Basin Bibliography**

Spatial Data

Following shapefiles are available

Cultural Data: The following culture shapefiles are located in the “The Permian Basin\Shapefiles\Culture”. They are also shown in the Kingdom Base Map under the Culture Inventory.

1. IHS_Main_Basin

2. IHS_Sub_Basin

3. AAPG_Province

4. States

5. Counties

6. Basement_Faults

7. Permian_NM_Sec

8. Permian_NM_Twp

9. Permian_TX_Blocks

10. Permian_TX_Survey

Play & Play Zone for the Permian Basin: Following play and play zone shapefiles are located in the “The Permian Basin\Shapefiles\Plays\Permian Basin.” A pre-labelled map of all the plays and zones is available in “The Permian Basin\IHS Model\Permian Basin Plays Map.lml” in the “Spatial Explorer” module.

1. Play_001_Rustler_Stratigraphic-Structural
2. Play_002_Tansill_Stratigraphic-Structural
3. Play_003_Yates_Stratigraphic-Structural
4. Play_004_Seven_Rivers_Stratigraphic-Structural
5. Play_005_Queen_Stratigraphic-Structural
6. Play_006_Grayburg_Stratigraphic-Structural
7. Play_007_San_Andres_Stratigraphic-Structural
8. Play_008_San_Andres_Clastic_Stratigraphic-Structural
9. Play_009_Lamar_Stratigraphic-Structural
10. Play_010_Bell_Canyon_Stratigraphic-Structural
11. Play_011_Cherry_Canyon_Stratigraphic-Structural
12. Play_012_Brushy_Canyon_Shale
13. Play_012a_Brushy_Canyon_Shale_Play_Zone
14. Play_013_Capitan_Reef_Stratigraphic-Structural
15. Play_014_Glorieta_Stratigraphic-Structural
16. Play_015_Clearfork_Stratigraphic-Structural
17. Play_016_Upper_Spraberry_Shale
18. Play_016a_Upper_Spraberry_Shale_Play_Zone
19. Play_017_Lower_Spraberry_Shale
20. Play_017_Lower_Spraberry_Shale_Play_Zone
21. Play_018_Tubb_Stratigraphic-Structural
22. Play_019_Dean_Stratigraphic-Structural
23. Play_020_Wichita_Albany_Stratigraphic-Structural
24. Play_021_Abo_Stratigraphic-Structural
25. Play_022_Avalon_Shale

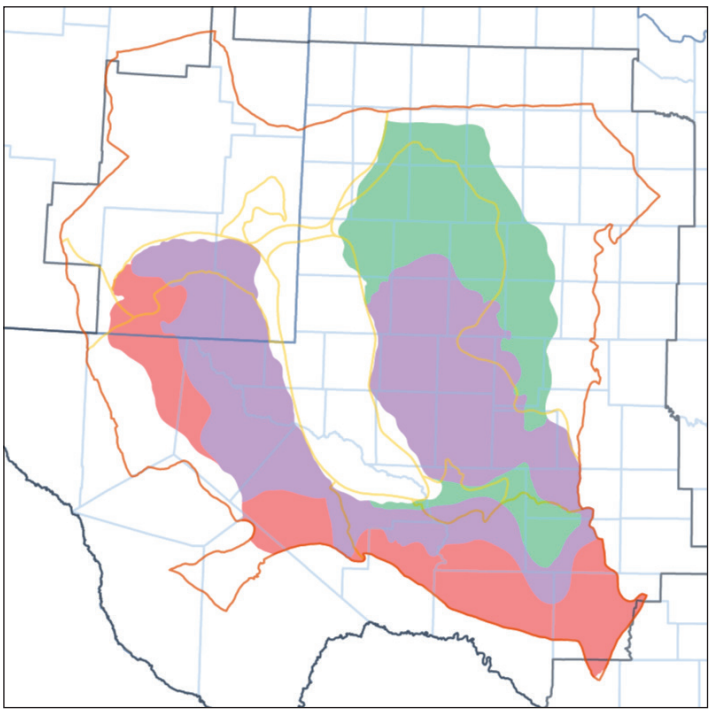
26. Play_022a_Avalon_Shale_Play_Zone
27. Play_023_Bone_Spring_Sandstone_1_Stratigraphic-Structural
28. Play_024_Bone_Spring_Sandstone_2_Stratigraphic-Structural
29. Play_025_Bone_Spring_Sandstone_3_Stratigraphic-Structural
30. Play_026_Wolfcamp_Stratigraphic-Structural
31. Play_027_Wolfcamp_Shale_Midland
32. Play_027a_Wolfcamp_Shale_Midland_Play_Zone
33. Play_028_Wolfcamp_Shale_Delaware
34. Play_028a_Wolfcamp_Shale_Delaware_Play_Zone
35. Play_029_Wolfcamp_Shale_Val_Verde
36. Play_029a_Wolfcamp_Shale_Val_Verde_Play_Zone
37. Play_030_Permian_Detrital_Stratigraphic-Structural
38. Play_031_Cisco_Stratigraphic-Structural
39. Play_032_Canyon_Stratigraphic-Structural
40. Play_033_Cline_Shale
41. Play_033a_Cline_Shale_Play_Zone
42. Play_034_Strawn_Stratigraphic-Structural
43. Play_035_Horseshoe_Atoll_Stratigraphic-Structural
44. Play_036_Atoka_Stratigraphic-Structural
45. Play_037_Upper_Morrow_Stratigraphic-Structural
46. Play_038_Lower_Morrow_Stratigraphic-Structural
47. Play_039_Pennsylvanian_Detrital_Stratigraphic-Structural
48. Play_040_Upper_Mississippian_Stratigraphic-Structural
49. Play_041_Barnett_Shale
50. Play_041a_Barnett_Shale_Play_Zone
51. Play_042_Lower_Mississippian_Stratigraphic-Structural
52. Play_043_Woodford_Shale
53. Play_043a_Woodford_Shale_Play_Zone
54. Play_044_Devonian_Stratigraphic-Structural
55. Play_045_Upper_Silurian_Stratigraphic-Structural
56. Play_046_Fusselman_Stratigraphic-Structural
57. Play_047_Montoya_Stratigraphic-Structural
58. Play_048_Simpson_Shale
59. Play_048a_Simpson_Shale_Play_Zone
60. Play_049_Ellenburger_Stratigraphic-Structural
61. Play_050_Cambrian_Stratigraphic-Structural
62. Play_051_Granite_Wash_Stratigraphic-Structural
63. Play_052_Precambrian_Stratigraphic-Structural
64. Permian_All_Plays

Play Zones (Shale plays only): Hydrocarbon maturity window delineating areas of:

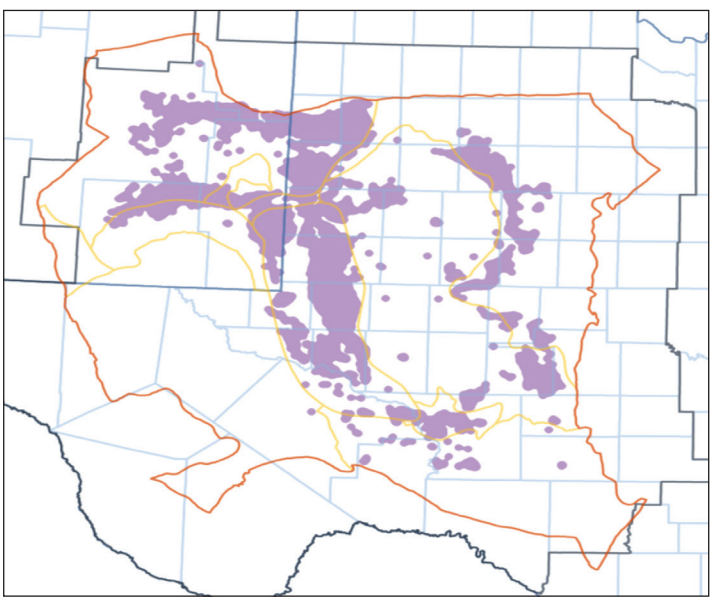
Oil Zone
Ro values between 0.55°- 0.9°, approximately corresponding to 15° - 35° API Gravity

Wet Gas Zone
Ro values between 0.9°- 1.4°, approximately corresponding to 35° - 50° API Gravity

Dry Gas Zone
Ro values between 1.4°- 4°, approximately corresponding to greater than 50° API Gravity



Shale (Continous Play)



Stratigraphic-Structural (Non-Continuous) Play

Play Shapefiles have following abbreviated attributes

1. TopAvgFT: Average top depth (MD) in feet
2. GrThkAvgFT: Average Gross Thickness in feet
3. TOCMin: Minimum Total Organic Carbon in wt%
4. TOCAvg: Average Total Organic Carbon in wt%
5. TOCMax: Maximum Total Organic Carbon wt%
6. Play_SQMI: Play area in square miles
7. OOIP_MMb: Original Oil in-Place in Millions of Barrels, resource estimated through IHS Markit's "TightEVal".
8. Cn_RF_O: Conventional Recovery Factor for Oil,
9. UCn_RF_O: Unconventional Recovery Factor for Oil
10. Tot_RF_O: Total Recovery Factor for Oil
11. Cn_Re_MMb: Conventional Recoverable Millions of Barrels
12. UCn_Re_MMb: Unconventional Recoverable Millions of Barrels
13. NHz_Pd_MMb: Non-Horizontal (Vertical and Directional) Cumulative Production in Millions of Barrels
14. Hz_Pd_MMb: Horizontal Cumulative Production in Millions of Barrels
15. Tot_Pd_MMb: Total Cumulative Production in Millions of Barrels
16. Cn_Rm_MMb: Conventional Remaining in Millions of Barrels
17. UCn_Rm_MMb: Unconventional Remaining in Millions of Barrels
18. Tot_Rm_MMb: Total Remaining in Millions of Barrels
19. OGIP_BCF: Original Gas in-Place in Billion Cubic Feet, resource estimated through IHS Markit's "TightEVal".
20. Cn_RF_G: Conventional Recovery Factor for Gas
21. UCn_RF_G: Unconventional Recovery Factor for Gas
22. Tot_RF_G: Total Recovery Factor for Gas
23. Cn_Re_BCF: Conventional Recoverable in Billion Cubic Feet
24. UCn_Re_BCF: Unconventional Recoverable in Billion Cubic Feet
25. Tot_Re_BCF: Total Recoverable in Billion Cubic Feet
26. NHz_Pd_BCF: Non-Horizontal (Vertical and Directional) Cumulative Production in Billion Cubic Feet.
27. Hz_Pd_BCF: Horizontal Cumulative Production in Billion Cubic Feet
28. Tot_Pd_Bcf: Total Cumulative Production in Billion Cubic Feet
29. Cn_Rm_BCF: Conventional Remaining in Billion Cubic Feet
30. UCn_Rm_BCF: Unconventional Remaining in Billion Cubic Feet
31. Tot_Rm_BCF: Total Remaining in Billion Cubic Feet

Play & Play Zone for the Delaware Benches: The following play and play zone shapefiles are located in the "The Permian Basin\Shapefiles\Plays\Delaware Benches." A pre-labelled map of all the plays & zones is available in "The Permian Basin\Delaware Benches\Delaware Benches Plays Map.lml" in the "Spatial Explorer" module.

1. Play_001_Bone_Spring_Limestone_Stratigraphic-Structural
2. Play_002_Leonard_Shale
3. Play_002a_Leonard_Shale_Play_Zone
4. Play_003_Avalon_Upper_Shale
5. Play_003a_Avalon_Upper_Shale_Play_Zone
6. Play_004_Avalon_Lower_Shale
7. Play_004a_Avalon_Lower_Shale_Play_Zone
8. Play_005_Bone_Spring_1_Sand_Stratigraphic-Structural
9. Play_006_Bone_Spring_1_Shale
10. Play_006a_Bone_Spring_1_Shale_Play_Zone
11. Play_007_Bone_Spring_2_Sand_Stratigraphic-Structural
12. Play_008_Bone_Spring_3_Sand_Stratigraphic-Structural
13. Play_009_Wolfcamp_A_Shale
14. Play_009a_Wolfcamp_A_Shale_Play_Zone
15. Play_010_Wolfcamp_B_Shale
16. Play_010a_Wolfcamp_B_Shale_Play_Zone
17. Play_011_Wolfcamp_C_Shale
18. Play_011a_Wolfcamp_C_Shale_Play_Zone
19. Play_012_Wolfcamp_D_Shale
20. Play_012a_Wolfcamp_D_Shale_Play_Zone
21. Delaware_Benches_All_Plays

Definitions

Shale Play (Continuous Type): Self-sourcing, filled during expulsion. It is also referred to as source-rock-reservoir-system implying that part of the generated hydrocarbons remain trapped within the source rock itself with minimal or no migration.

The extent of a shale play is defined by area where the concerned interval is greater than 10 feet in true vertical thickness, between 2,000-20,000 feet in true vertical depth and between 0.55°- 4° in Vitrinite Reflectance (Ro) values.

Stratigraphic-Structural Play (Non-Continuous Type): Non-self-sourced reservoirs disconnected from a mature source rock, filled during secondary and tertiary migration and spatially confined by a conventional trap mechanism. In the Permian Basin, these conventional reservoirs have gone through secondary and even tertiary EOR, thus further production is likely to be through short lateral and low volume fracs, offering lower risk, better upside potential and ultimately lower cost.

The extent of a Stratigraphic-Structural Play is defined by 1.5 to 2 miles buffer around productive and show wells from the concerned interval.

About IHS Markit

IHS Markit (Nasdaq: INFO) is a world leader in critical information, analytics and solutions for the major industries and markets that drive economies worldwide. The company delivers next-generation information, analytics and solutions to customers in business, finance and government, improving their operational efficiency and providing deep insights that lead to well-informed, confident decisions. IHS Markit has more than 50,000 key business and government customers, including 85 percent of the Fortune Global 500 and the world's leading financial institutions. Headquartered in London, IHS Markit is committed to sustainable, profitable growth.

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