- Best Practice -

Custom Coordinate System in Petrel 2018-2022

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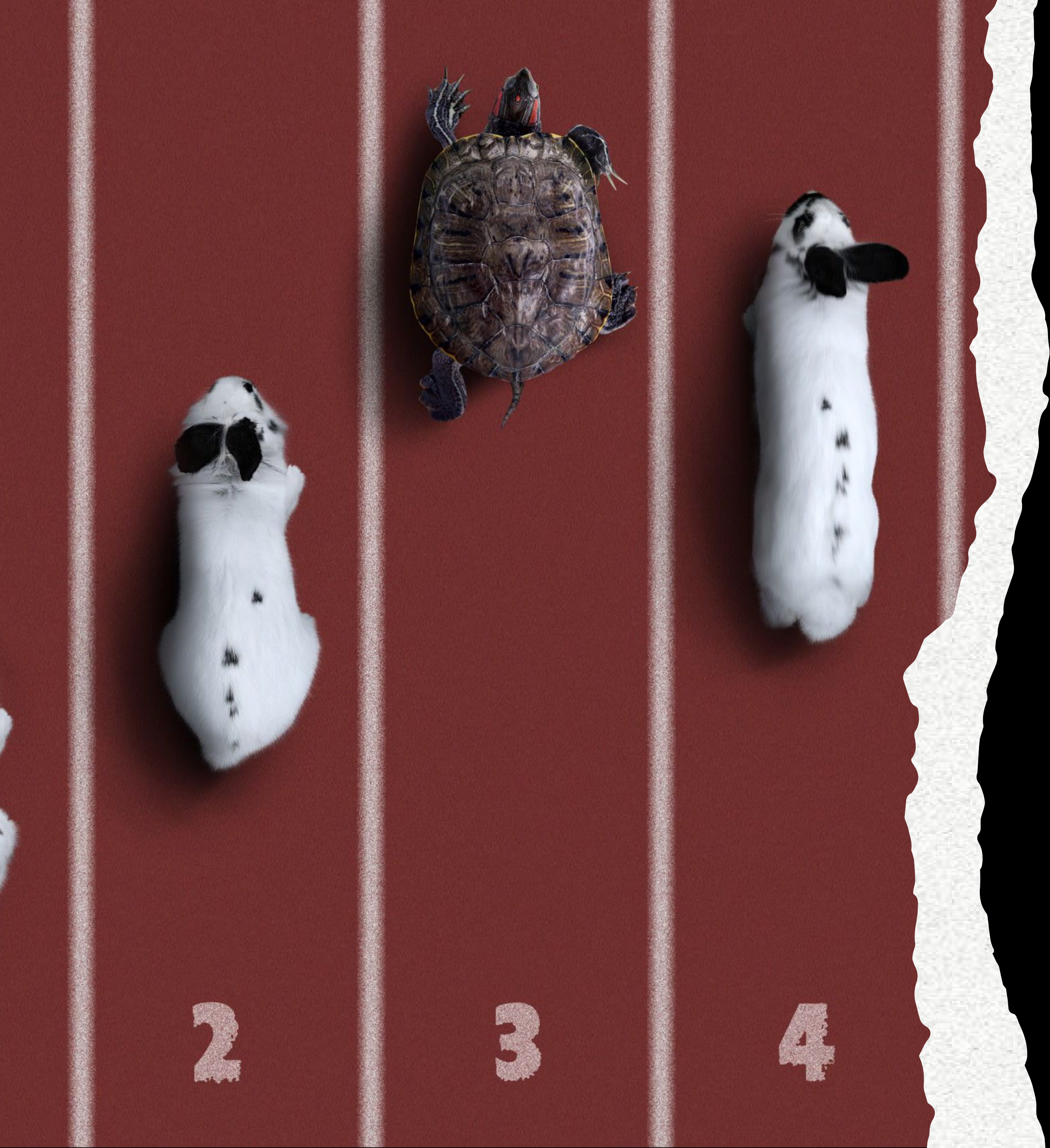
Scenarios to Apply a Custom Coordinate System

Business/Operation Scenarios and Proposal

1. You are going to work on a dataset (seismic, well, or culture), which does not fall into any natively built-in Coordinate Reference Systems ("CRS"). Then you may position your datapoints wrongly.

2. You failed to import some well/seismic/culture data into your working project, due to the to-be-imported data bearing a different CRS against your working project.

Proposed Solution: Build a **Custom CRS**



A Primer of Coordinate Systems

What’s a Coordinate System?

Coordinate Reference System (CRS):

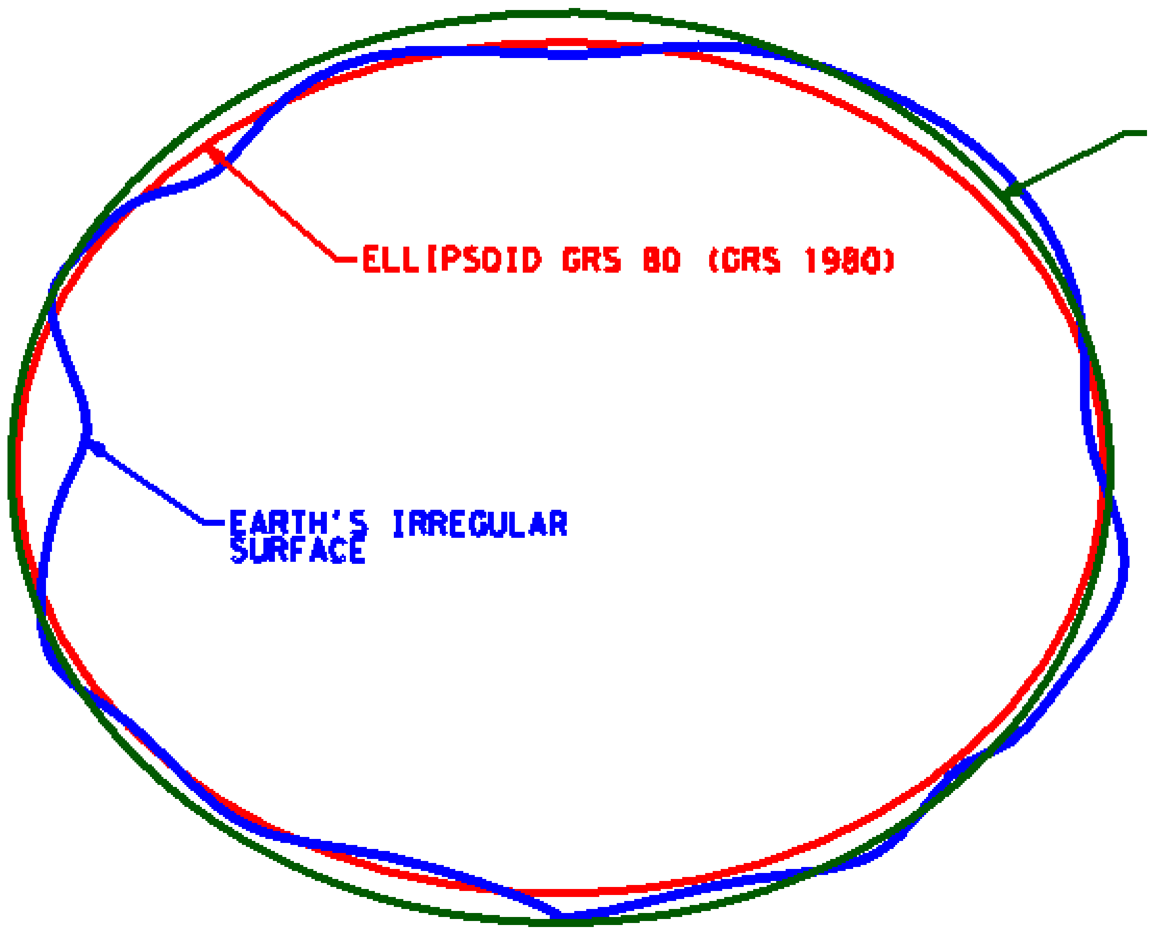
- **The mechanism to define, how the two-dimensional, projected map is related to real locations on the earth**, with the help of coordinates.

Two Types of CRS:

- **Geographic** Coordinate System: Latitude / Longitude
- **Projected** Coordinate System: X/Y values

Ellipsoid:-

a flattened three-dimensional ellipse with smooth surface to approximate the earth



Ellipsoid:-

a flattened three-dimensional ellipse with smooth surface to approximate the earth

Typically, an ellipsoid has its own specific parameters, such as, **semi-major axis** (a in meters), **semi-minor axis** (b in meters), and **inverse flattening** (1/f =a/(a-b)).

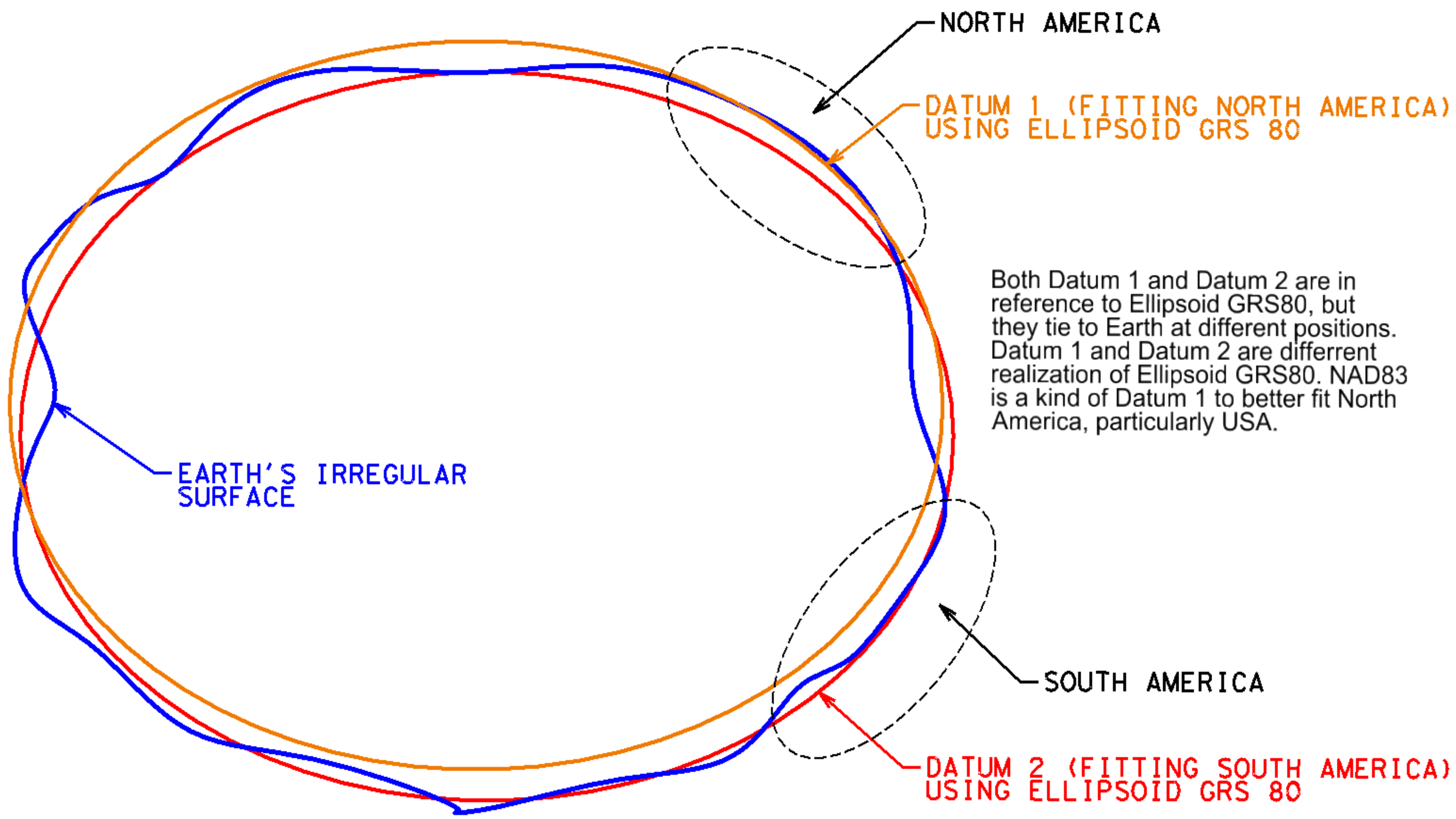
Ellipsoid	Semi-Major Axis a (m)	Semi-Minor Axis b (m)	Inverse Flattening 1/f
GRS80	6378137.000	6356752.314140356	298.257222101
WGS84	6378137.000	6356752.314245179	298.257223563
International 1924	6378388.000	6356911.946	297.000
Clarke 1880 (RGS)	6378249.145	6356514.870	293.465

Datum:-
a model of the shape of the earth

- An ellipsoid has different realizations, which are different **ways to position itself relative to Earth depending on where its center is located**.
- **Each realization is called a datum** and therefore an ellipsoid may have different datums.
- Simply, a Datum is **a model of the shape of the earth** per se.
- Typical datum: **WGS84** (the name is same as its ellipsoid); **ED50** (its ellipsoid: International 1924/Hayford); **Nord Sahara** (its ellipsoid: Clarke 1880 RGS).

Datum:-

a model of the shape of the earth



Both Datum 1 and Datum 2 are in reference to Ellipsoid GRS80, but they tie to Earth at different positions. Datum 1 and Datum 2 are differrent realization of Ellipsoid GRS80. NAD83 is a kind of Datum 1 to better fit North America, particularly USA.

Fun Fact -

Lat/Long values of a physical location differ from Datum to Datum.

Since longitude and latitude values are tied with datums, **a location's longitude and latitude values in reference to Datum WGS84 are not same as in reference to Datum NAD83, nor Datum ED50.**

City	WGS84		NAD83	
	Latitude	Longitude	Latitude	Longitude
Calgary, AB	51°02'55.0140"	-114°04'15.0456"	51°02'55.0045"	-114°04'15.0608"
St Louis, MO	38°37'37.211"	-90°11'57.847"	38°37'37.185"	-90°11'57.825"
Houston, TX	29°44'59.665"	-95°21'30.316"	29°44'59.646"	-95°21'30.290"
Pasadena, CA	34°09'22.007"	-118°07'54.995"	34°09'22.007"	-118°07'54.951"

Projection:-

the means by which you display the coordinate system and your data on a flat surface.

Mathematical calculations are used to convert the coordinate system used on the curved surface of earth to one for a flat surface.

A 3D element will lose at least one of its three characteristics – angle, area, and distance when being projected onto 2D surface, NO MATTER which projection method is used.

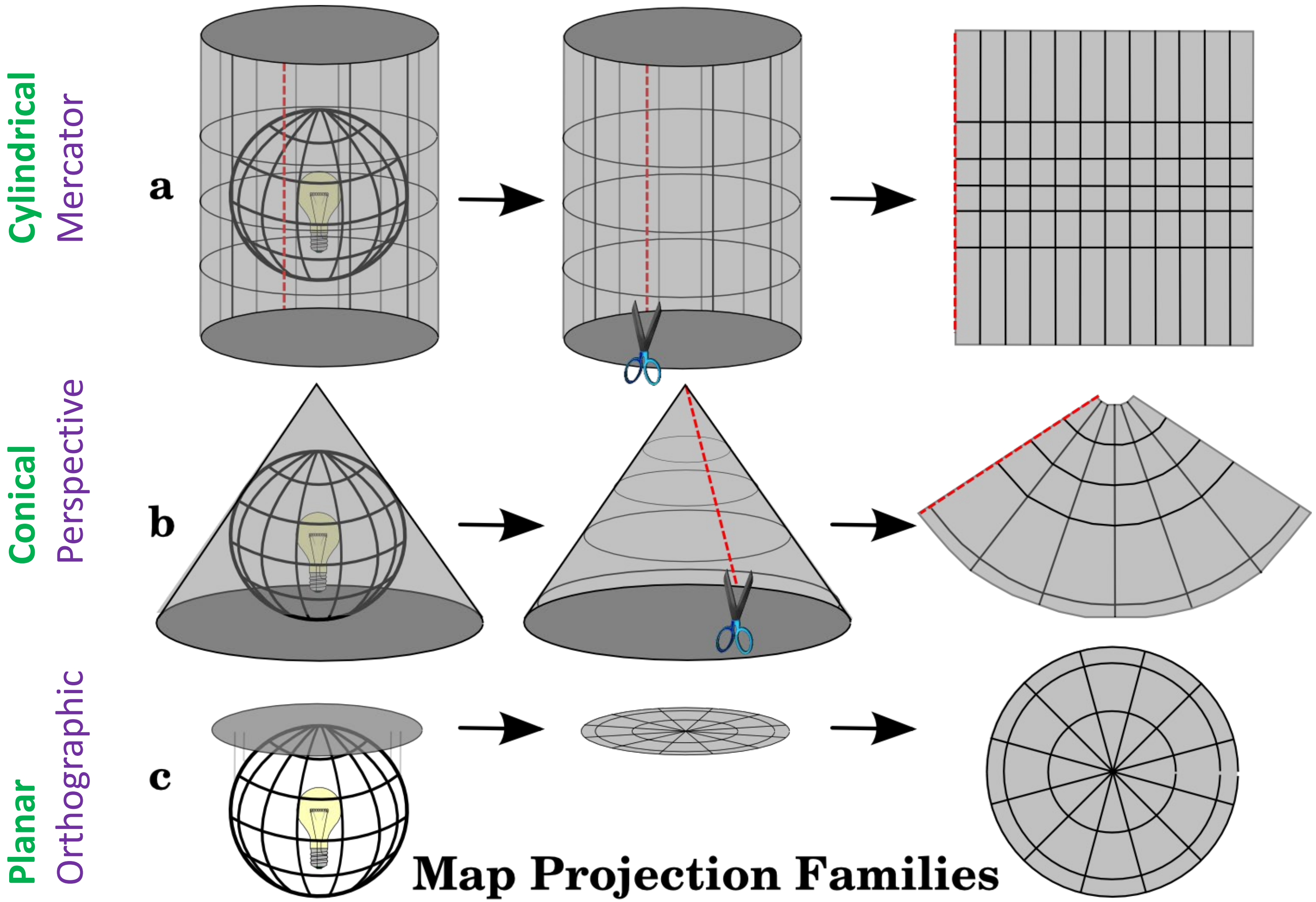
The coordinate system on 2D surface is called a Projected Coordinate System ("PCS") with coordinate unit of foot, US foot, or meter.

Projection:-

3 Types of Projection Methods: Cylindrical, Conical, and Planar

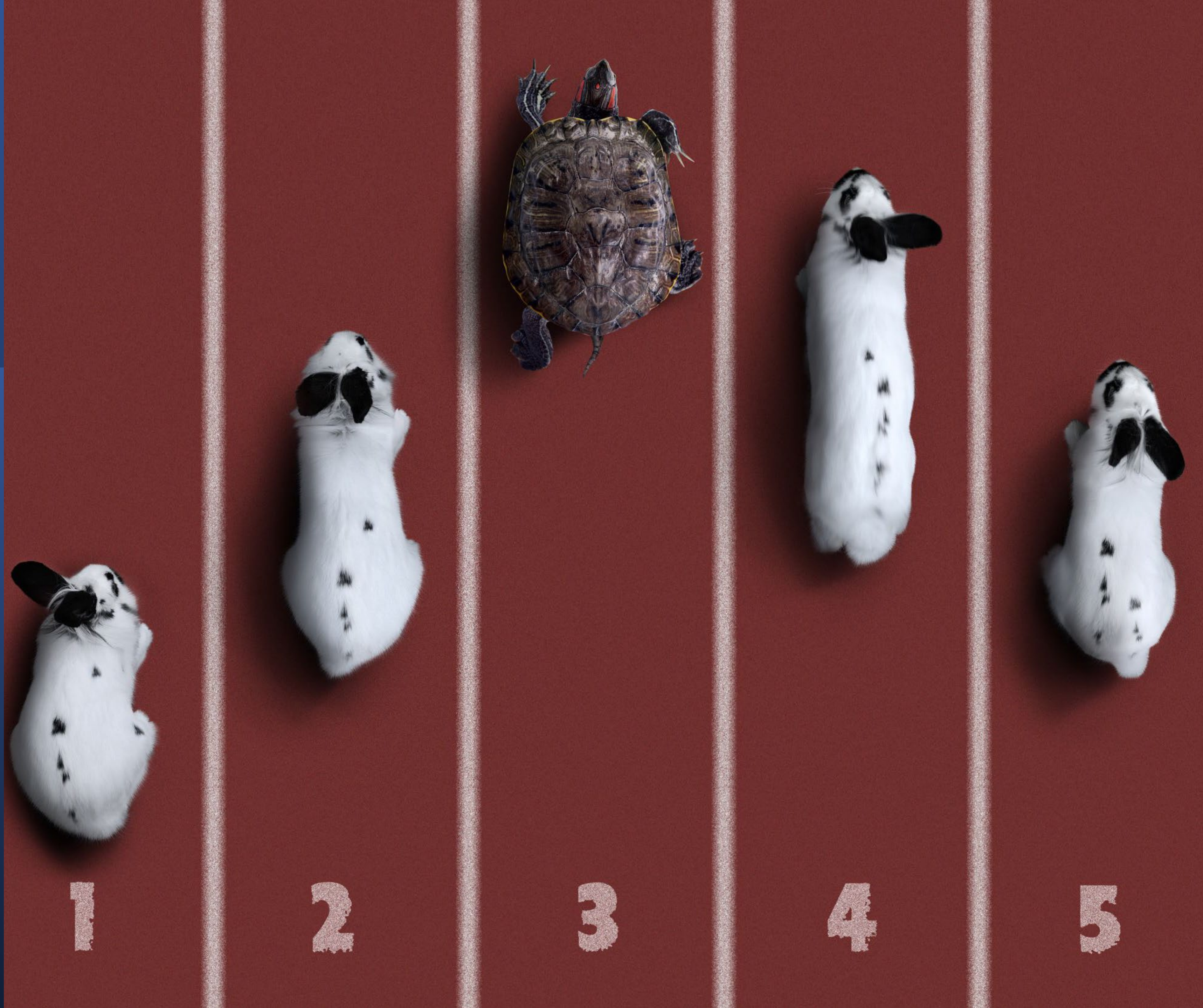
Universal Transverse Mercator ➔

Lambert Conformal Conic ➔



How to Create Custom CRS in

Schlumberger
Petrel
2018-2022



Procedures to Create a Custom CRS in Any Application

1. INQUIRE BUSINESS NEEDS & COLLECT DATA
2. CHOOSE/CREATE AN APPROPRIATE ELLIPSOID
3. DETERMINE / CREATE A DATUM
4. DEFINE A CUSTOM GEOGRAPHIC / GEODETIC COORDINATE SYSTEM (“GCS”)
5. DETERMINE THE TRANSFORM FROM A LOCAL GCS TO WGS84 GCS
6. DEFINE / CREATE A PROJECTED COORDINATE SYSTEM (“PCS”)

Procedures to Create a Custom CRS in Petrel 2018-2021

1. Inquire Business Needs & Collect Data

2. Select an Appropriate Ellipsoid

3. Determine / Create a Custom Datum

4. Prepare the WKT & Define Geographic / Projected CRS

5. Create a Custom Transform from a Local GCRS to WGS84

6. Define / Create a Projected Coordinate System

(1) Inquire Business Needs & Collect Data

AGOCO Lambert Datum Using 2 Parallels	
Ellipsoid	Clarke 1880
Projection	Lambert Conical Orthomorphic
Latitude of Origin	31° N
Longitude of Origin	18° E
Scale Factor @ the Origin	0.99938949
First Parallel	33° 00' 00''
Second Parallel	28° 59' 08.3''
False Northing	550,000m
False Easting	1,000,000m
Semi Major Axis	6,378,249.145m
Reciprocal Flattening (1/f)	296.465
Central Meridian	18° E
Zone	Libya North

1. A 3D Seismic cube of Concession NC-100 of west Libya has a projection of Lambert Conformal Conic ("LCC"), instead of the commonly used UTM Projection, and AGOCO-cooked Datum based on Clarke 1880 Ellipsoid.

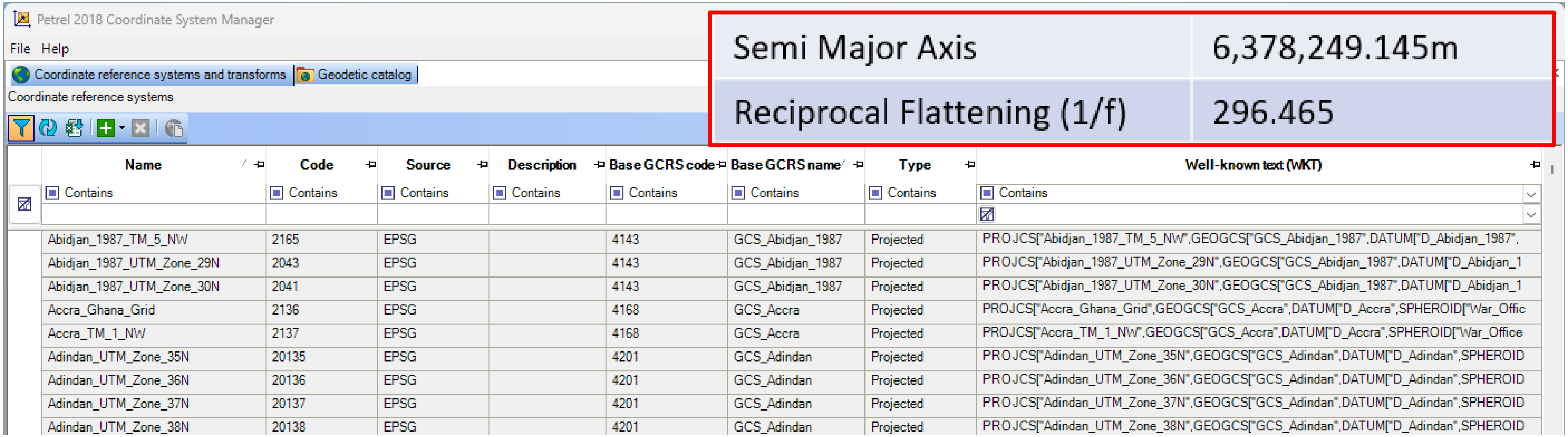
2. Failed to load the seismic cube into Petrel or Kingdom due to lack of pre-defined Projected CRS related to that specific cube.

3. Plan to create a Custom Projected CRS ("PCRS") and Transform for converting or loading up such seismic cube into Petrel 2018-2021.

(2) Select an Appropriate Ellipsoid

Launch Petrel Coordinate System Manager → "Coordinate reference systems and transforms" tab → "Coordinate reference systems" section

As per the geodesy expertise I gained before, plus looking at the ArcGIS database, EPSG database and the ellipsoid parameters from AGOCO: typically, the "Semi Major Axis", "Semi Minor Axis", and "Reciprocal Flattening (1/f)" , this is the ellipsoid of "Clarke 1880 RGS"; then we shall choose "Clarke 1880 (RGS)" as our ellipsoid (EPSG:7012).



Semi Major Axis	6,378,249.145m
Reciprocal Flattening (1/f)	296.465

Name	Code	Source	Description	Base GCRS code	Base GCRS name	Type	Well-known text (WKT)
Contains	Contains	Contains	Contains	Contains	Contains	Contains	Contains
Abidjan_1987_TM_5_NW	2165	EPSG		4143	GCS_Abidjan_1987	Projected	PROJCS["Abidjan_1987_TM_5_NW",GEOGCS["GCS_Abidjan_1987",DATUM["D_Abidjan_1987",
Abidjan_1987_UTM_Zone_29N	2043	EPSG		4143	GCS_Abidjan_1987	Projected	PROJCS["Abidjan_1987_UTM_Zone_29N",GEOGCS["GCS_Abidjan_1987",DATUM["D_Abidjan_1
Abidjan_1987_UTM_Zone_30N	2041	EPSG		4143	GCS_Abidjan_1987	Projected	PROJCS["Abidjan_1987_UTM_Zone_30N",GEOGCS["GCS_Abidjan_1987",DATUM["D_Abidjan_1
Accra_Ghana_Grid	2136	EPSG		4168	GCS_Accra	Projected	PROJCS["Accra_Ghana_Grid",GEOGCS["GCS_Accra",DATUM["D_Accra",SPHEROID["War_Offic
Accra_TM_1_NW	2137	EPSG		4168	GCS_Accra	Projected	PROJCS["Accra_TM_1_NW",GEOGCS["GCS_Accra",DATUM["D_Accra",SPHEROID["War_Office
Adindan_UTM_Zone_35N	20135	EPSG		4201	GCS_Adindan	Projected	PROJCS["Adindan_UTM_Zone_35N",GEOGCS["GCS_Adindan",DATUM["D_Adindan",SPHEROID
Adindan_UTM_Zone_36N	20136	EPSG		4201	GCS_Adindan	Projected	PROJCS["Adindan_UTM_Zone_36N",GEOGCS["GCS_Adindan",DATUM["D_Adindan",SPHEROID
Adindan_UTM_Zone_37N	20137	EPSG		4201	GCS_Adindan	Projected	PROJCS["Adindan_UTM_Zone_37N",GEOGCS["GCS_Adindan",DATUM["D_Adindan",SPHEROID
Adindan_UTM_Zone_38N	20138	EPSG		4201	GCS_Adindan	Projected	PROJCS["Adindan_UTM_Zone_38N",GEOGCS["GCS_Adindan",DATUM["D_Adindan",SPHEROID

(3) Determine/Create a Custom Datum

Launch Petrel Coordinate System Manager → ”Coordinate reference systems and transforms” tab → “Coordinate reference systems” section

Apart from what we have selected in previous step, we can also define/customize the Datum as “D_AGOCO” by concatenating the Ellipsoid, Prime Meridian and Unit.

In Petrel, managing the GCS, PCS, or transforms is a tough task since Petrel has no such convenient toolset as ArcGIS, Blue Marble Geographics or Kingdom, then we have to use a text editor (Don’t use Microsoft Word, nor WordPad) to handle the **WKT** (Well Known Text) script:

```
GEOGCS["GCS_AGOCO",
        DATUM["D_AGOCO", SPHEROID["Clarke_1880",6378249.145,293.465], AUTHORITY[“EPSG”,7012]],
        PRIMEM["Greenwich",0.0],
        UNIT["Degree",0.0174532925199433],
        AUTHORITY["AGOCO",700003]]
```

You can google out how to write a WKT file.

(4A) Prepare the WKT & Define Geographic/Projected CRS

Prepare the WKT for generating the Projected CRS named as "Libya-North: Clarke-1880-LCC-1SP" concatenating the just-defined Geographic CRS and the projection parameters.

C:\Users\mzou\Downloads\CRS\4_Practice in SOC\1_PCRS_Libya-North-CL80-LCC-2SP_SOC-EXP_800001.WKT • - Sublime Text

File Edit Selection Find View Goto Tools Project Preferences Help

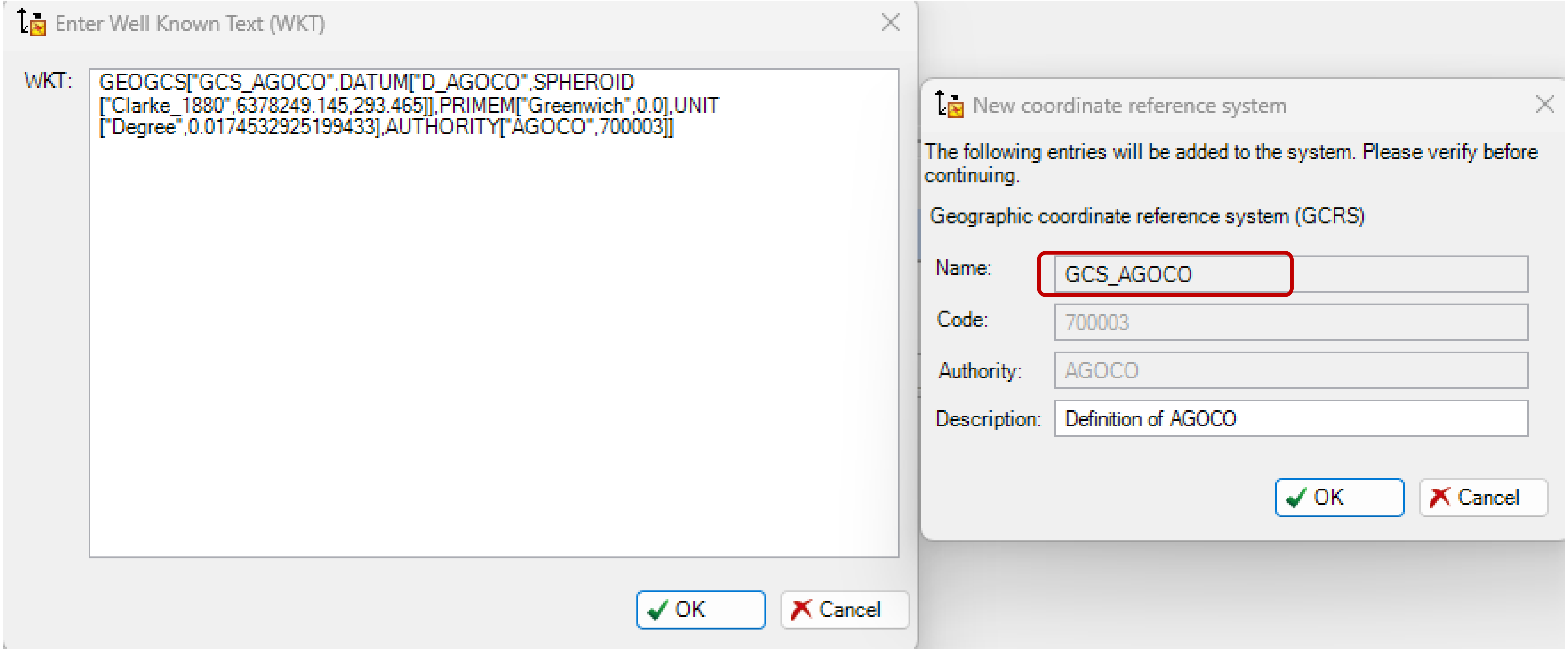
1_PCRS_Libya-North-CL80-LCC-2SP_SOC-EXP_800001.WKT

```
PROJCS["Libya-North: Clarke-1880-LCC-1SP",
    GEOGCS["GCS_Nord_Sahara_1959",
        DATUM["D_Nord_Sahara_1959",SPHEROID["Clarke_1880_RGS",6378249.145,293.465]],
        PRIMEM["Greenwich",0.0],
        UNIT["Degree",0.0174532925199433],
        AUTHORITY["EPSG",4307]],
    PROJECTION["Lambert_Conformal_Conic"],
    PARAMETER["False_Easting",1000000.0],
    PARAMETER["False_Northing",550000.0],
    PARAMETER["Central_Meridian",18.0],
    PARAMETER["Scale_Factor",0.99938949],
    PARAMETER["Latitude_Of_Origin",31.0],
    UNIT["Meter",1.0],
    AUTHORITY["SOC-EXP",800001]]
```

Consult to a Geodesist for technical details; Please stay hands-off if you have not/never established a good foundation of Geodesy.

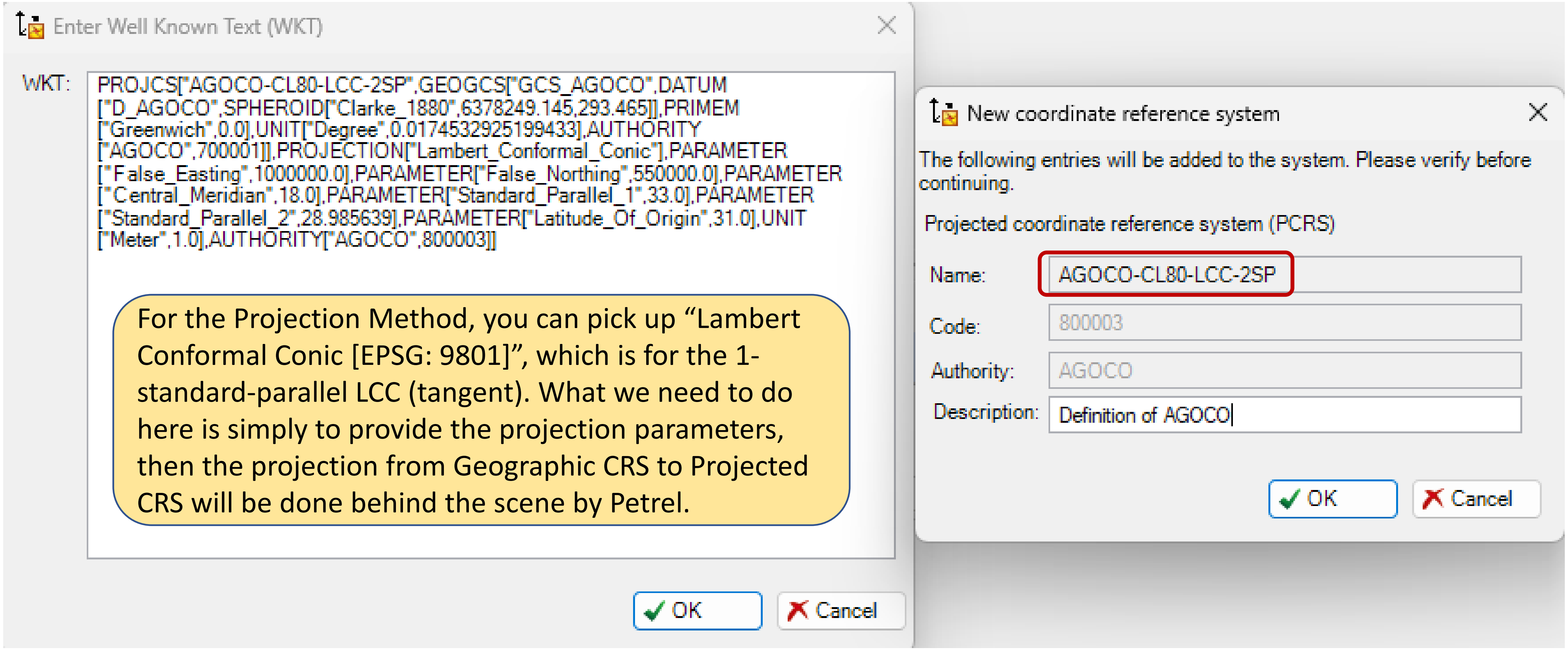
(4B) Prepare the WKT & Define Geographic/Projected CRS

At the header of “Coordinate reference systems” section → Click “+” sign → Enter the WKT for Geographic CRS and follow the steps as below.



(4C) Prepare the WKT & Define Geographic/Projected CRS

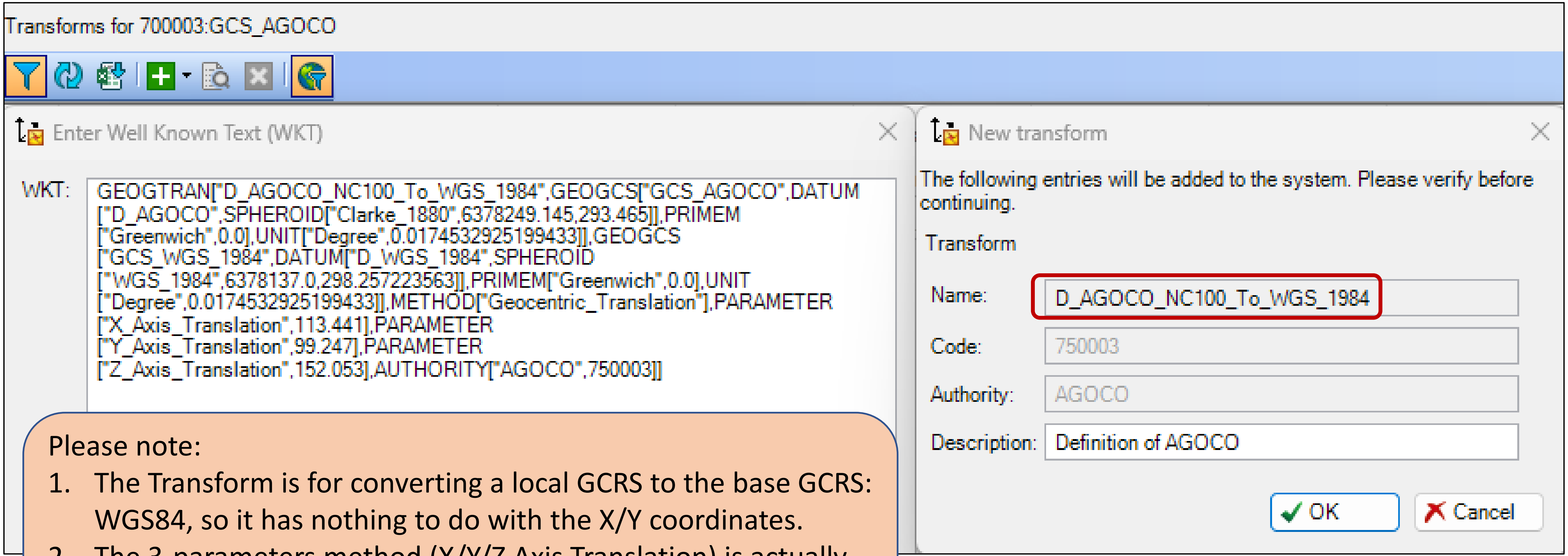
At the header of "Coordinate reference systems" section → Click "+" sign → Enter the WKT for Projected CRS and follow the steps as below, naming as "AGOCO-CL80-LCC-2SP".



For the Projection Method, you can pick up "Lambert Conformal Conic [EPSG: 9801]", which is for the 1-standard-parallel LCC (tangent). What we need to do here is simply to provide the projection parameters, then the projection from Geographic CRS to Projected CRS will be done behind the scene by Petrel.

(5) Create a Custom Transform from a Local GCRS to WGS84

Prepare the WKT for the Transform → Switch to “Transforms” section → Click “+” sign to create the Transform by following the steps below, naming the transform as “D_AGOCO_NC100_to_WGS_1984”.



Please note:

1. The Transform is for converting a local GCRS to the base GCRS: WGS84, so it has nothing to do with the X/Y coordinates.
2. The 3-parameters method (X/Y/Z Axis Translation) is actually good enough if the local ellipsoid/datum is not too different from WGS84, otherwise a 7-parameters method is preferred.

(6A) Create a Projected Coordinate System (“PCS”)

Switch to “Geodetic catalog” tab → Click the “+” sign to create a new conflation policy.

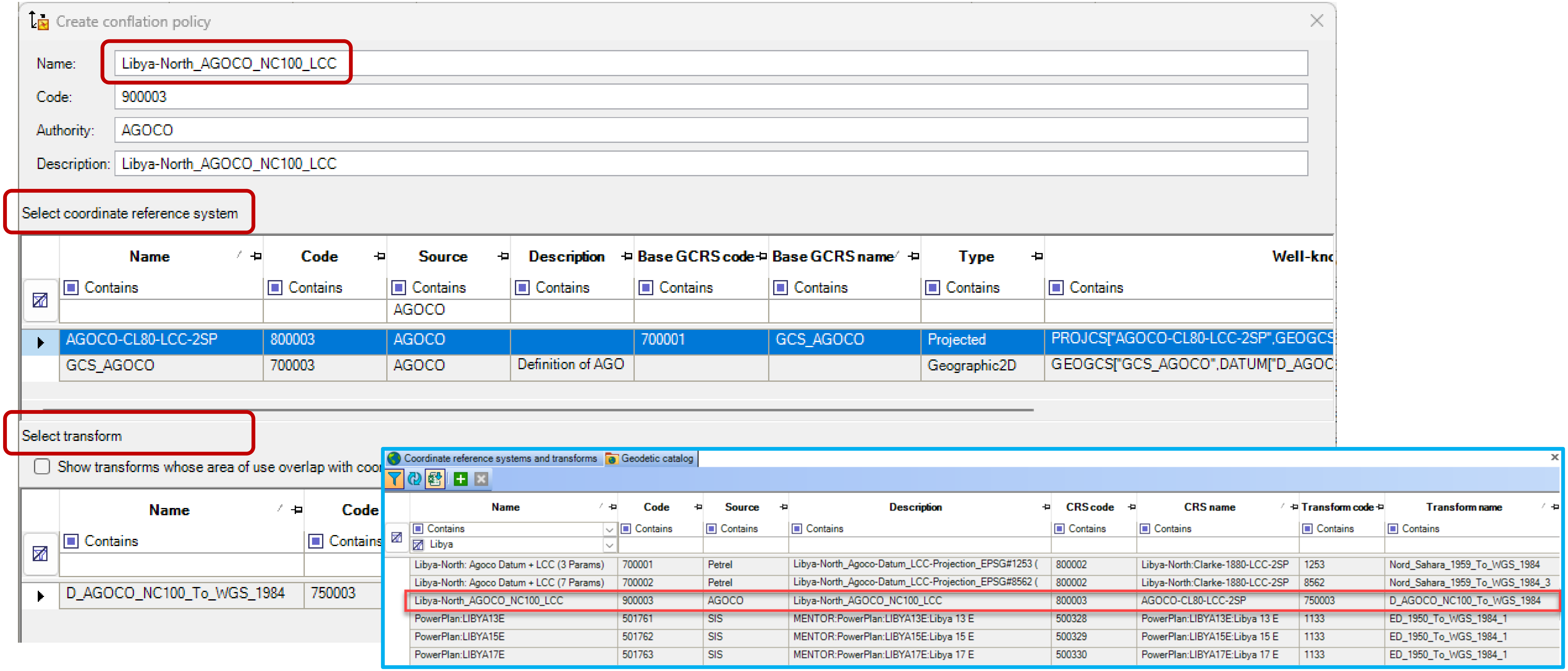
Coordinate reference systems and transforms | Geodetic catalog

Name	Code	Source	Description	CRS code	CRS name
Contains	Contains	Contains	Contains	Contains	Contains
Libya					
PowerPlan:LIBYA13E	501761	SIS	MENTOR:PowerPlan:LIBYA13E:Libya 13 E	500328	PowerPlan:LIBYA13E:Libya 13 E
PowerPlan:LIBYA15E	501762	SIS	MENTOR:PowerPlan:LIBYA15E:Libya 15 E	500329	PowerPlan:LIBYA15E:Libya 15 E
PowerPlan:LIBYA17E	501763	SIS	MENTOR:PowerPlan:LIBYA17E:Libya 17 E	500330	PowerPlan:LIBYA17E:Libya 17 E
PowerPlan:LIBYA19E	501764	SIS	MENTOR:PowerPlan:LIBYA19E:Libya 19 E	500331	PowerPlan:LIBYA19E:Libya 19 E
PowerPlan:LIBYA21E	501765	SIS	MENTOR:PowerPlan:LIBYA21E:Libya 21 E	500332	PowerPlan:LIBYA21E:Libya 21 E
PowerPlan:LIBYA23E	501766	SIS	MENTOR:PowerPlan:LIBYA23E:Libya 23 E	500333	PowerPlan:LIBYA23E:Libya 23 E
Libya-North: Agoco Datum + LCC (3 Params)	700001	Petrel	Libya-North_Agoco-Datum_LCC-Projection_EPSG#1253 (For UTM32N only - Longitud	800002	Libya-North:Clarke-1880-LCC-2SP

Petrel uses Conflation Policy to glue the definition of a Projected CRS with the custom Transform. This is very different (even strange) approach comparing to other applications, such as, ArcGIS, Blue Marble Geographics’ Global Mapper, Kingdom, etc.

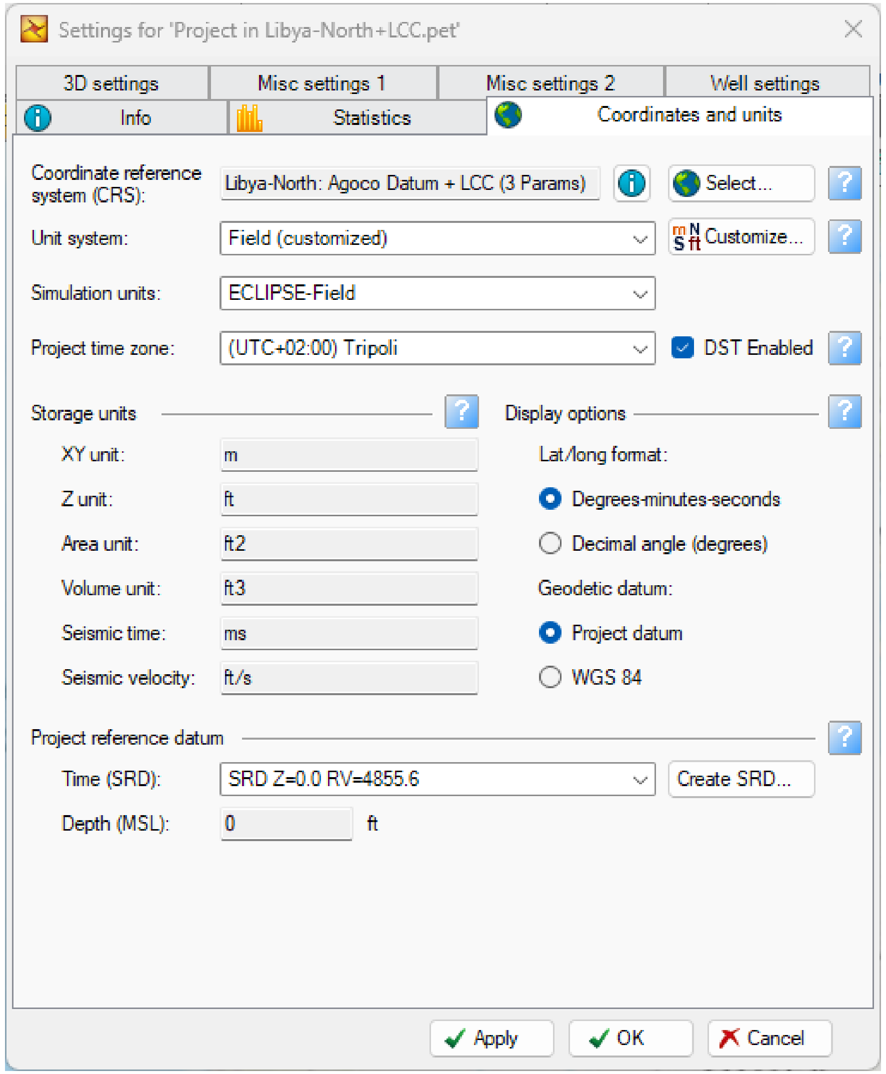
(6B) Create a Projected Coordinate System ("PCS")

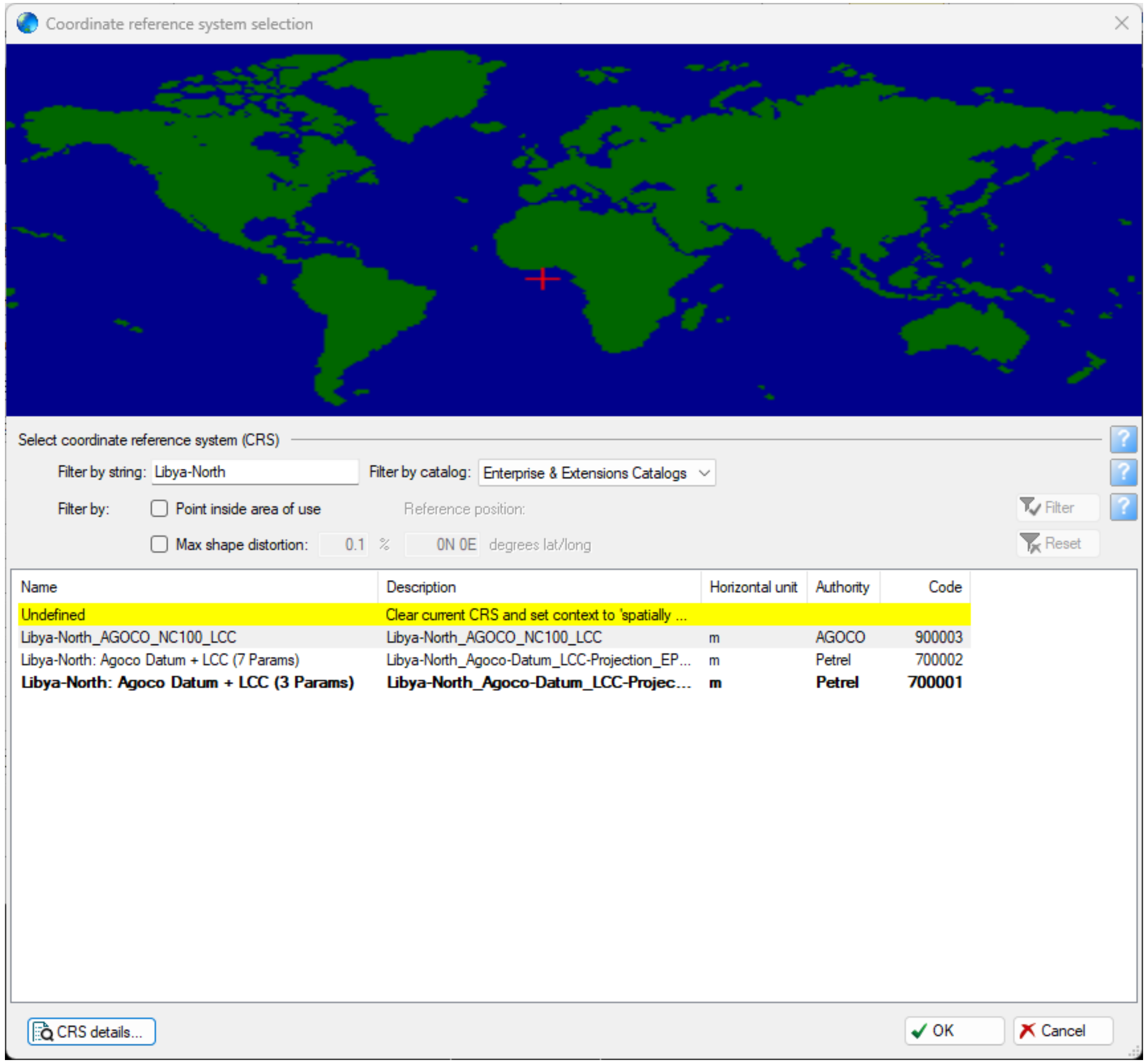
At the "Create conflation policy" window → Name the conflation policy as "Libya-North_AGOCO_NC100_LCC" → Pick up the newly defined Projected CRS in step (4C) and its related Transform created in step (5).



(6C) Define / Create a Projected Coordinate System ("PCS")

Verify the Custom CRS by creating a new Petrel project, select the custom Projected CRS.

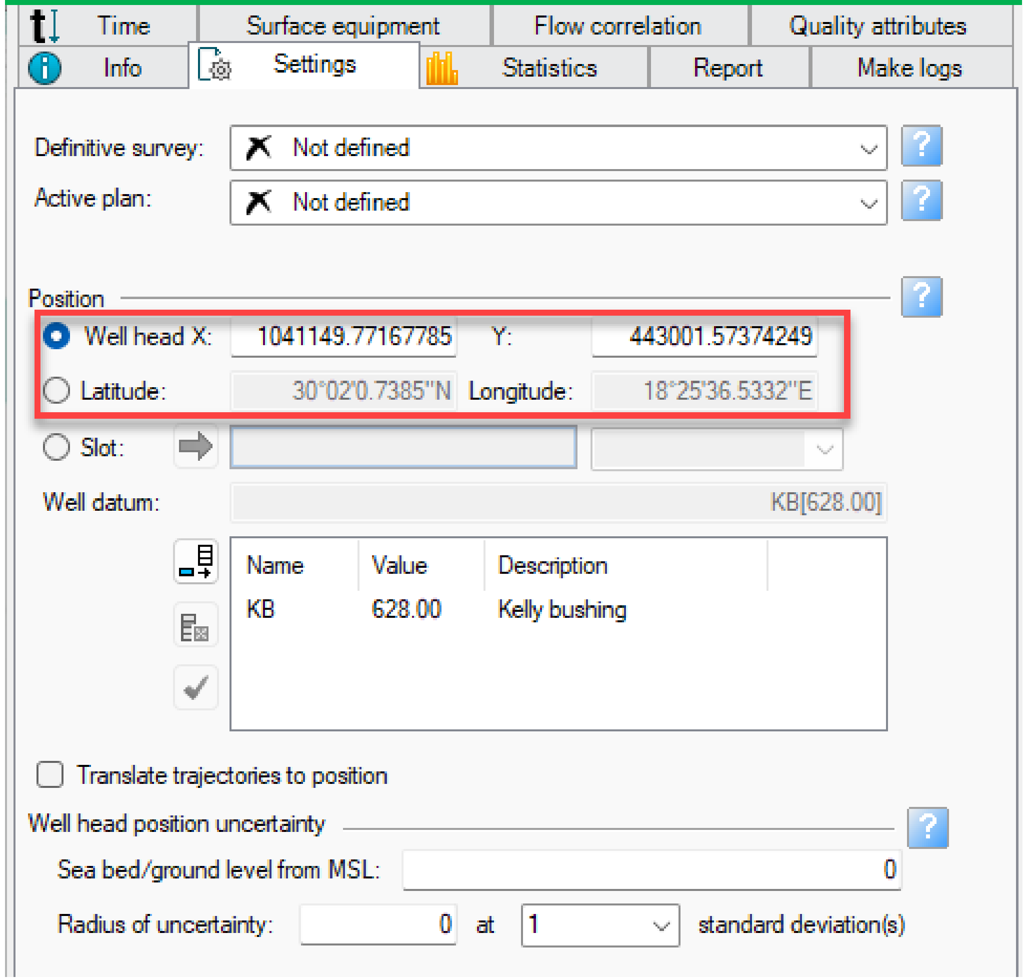


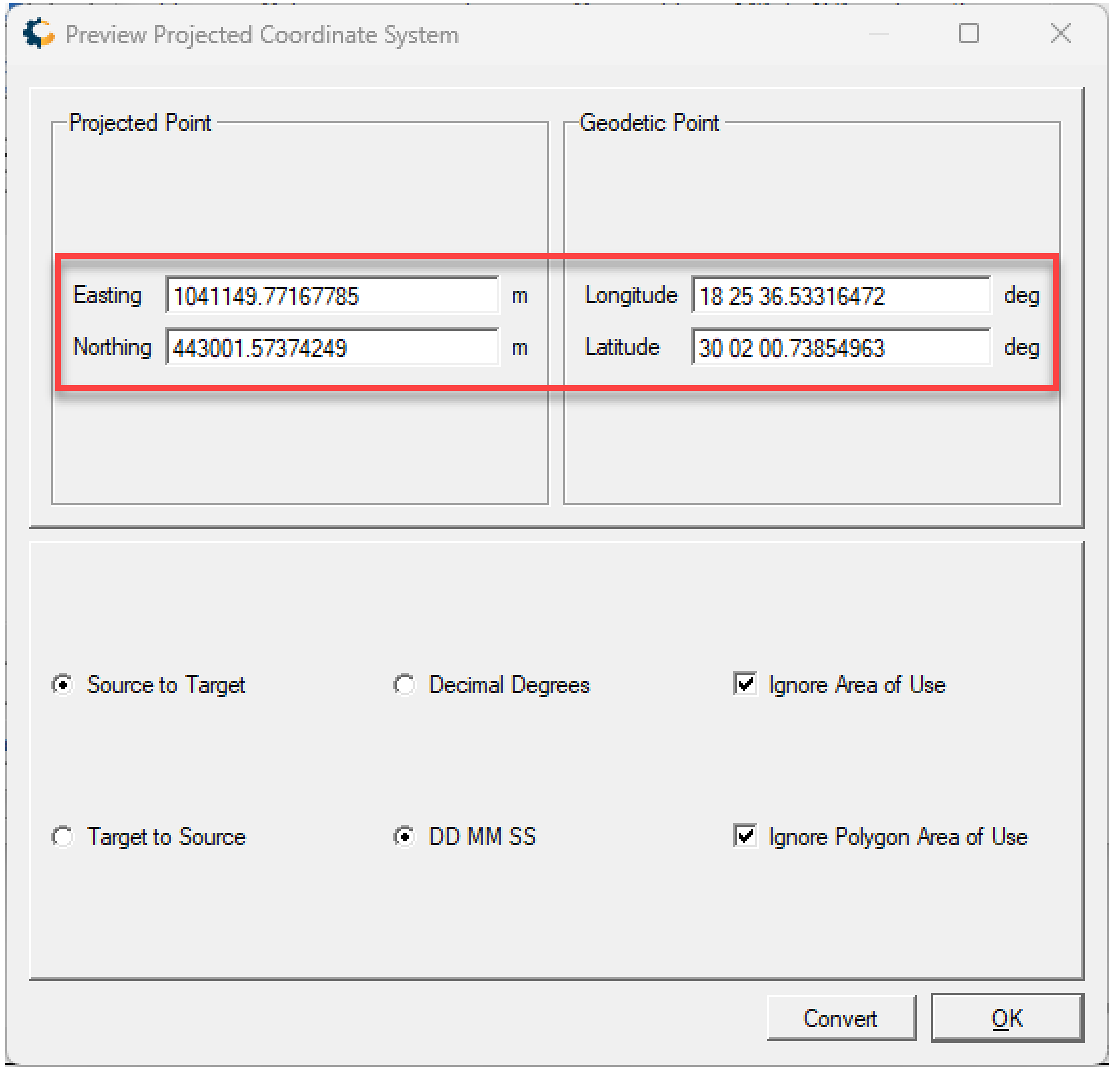


(6D) Define / Create a Projected Coordinate System ("PCS")

The results at Well Property window(Left) demonstrates a very precise conversion versus the results from Kingdom (Right) as well as other system, e.g., ArcGIS, Blue Marble Geographics' Global Mapper.

Well Property window in Petrel





Conclusions: Custom CRS is Doable/Applicable in Petrel

Application / Version	Able to Customize Coordinate System?
Petrel 2018	Yes, tested Okay, results verified against Kingdom/ArcGIS.
Petrel 2021	Yes, tested Okay, results verified against Kingdom/ArcGIS.
Petrel 2022	Yes, tested Okay, results verified against Kingdom/ArcGIS.

Note: Coordinate Reference System (“CRS”) and Coordinate System (“CS”) are interchangeably used in line with the industry practice.

The End

References	
EPSG website	www.epsg.io
ArcGIS website	www.arcgis.com
Blue Marble Geographics	www.bluemarblegeo.com
Wikipedia	www.wikipedia.org
Schlumberger Ltd.	Petrel Help and Manual, 2018-2022
IHS-Markit (S&P Global)	Kingdom Help and Manual, 2017/2021