GIS based database of geological/reserve extent maps for E&P Companies

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Presentation Overview:

- **Introduction to creation of corporate database of**

Ø **Interpretation maps (preserved as CGM files)**

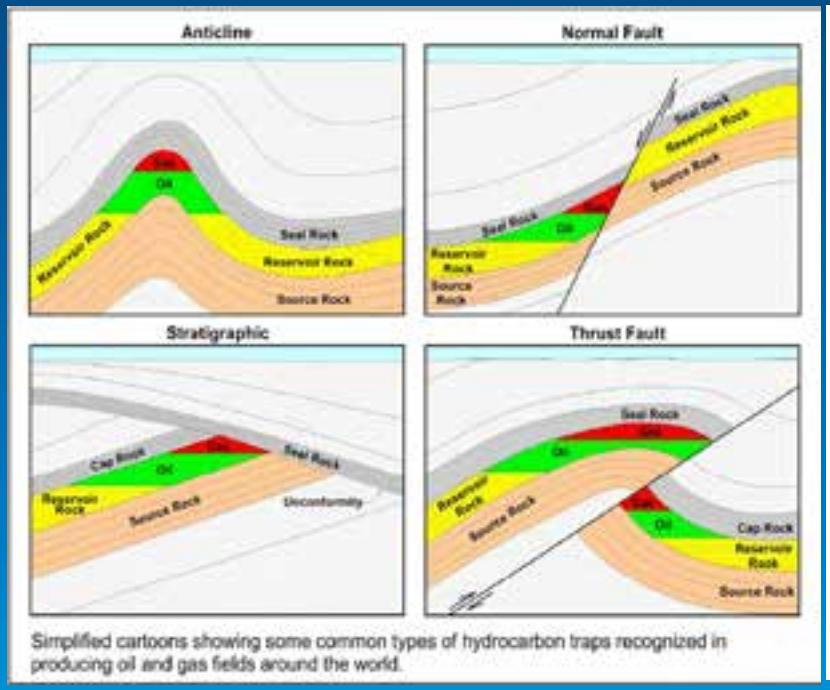
Ø **Reserve estimate maps (preserved also as .cdr or .tiff files)**

for Oil & Gas E&P companies

- **Database is created in Geographical Information System (GIS) – Why?**
- **What are Bezier curves and its relevance to this database?**
- **Importance of the database**
- **Conclusion**

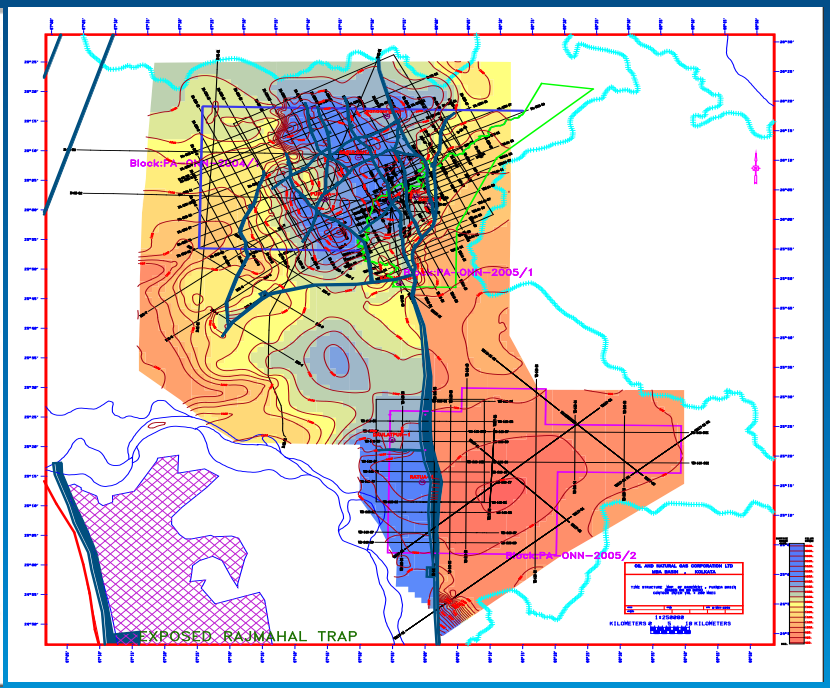
Introduction/Objectives:

Creation of corporate database of maps related to Oil Exploration & Production (E&P)



Simplified cartoons showing some common types of hydrocarbon traps recognized in producing oil and gas fields around the world.

Possible habitat of oil and gas



Geological and Geophysical interpretation maps

Introduction (Contd...) :

Why GIS (Geographical Information System)?

- Database is created in GIS because of its “layering” capability – different features of a map can be stored in separate layers

Why is the database on GIS important?

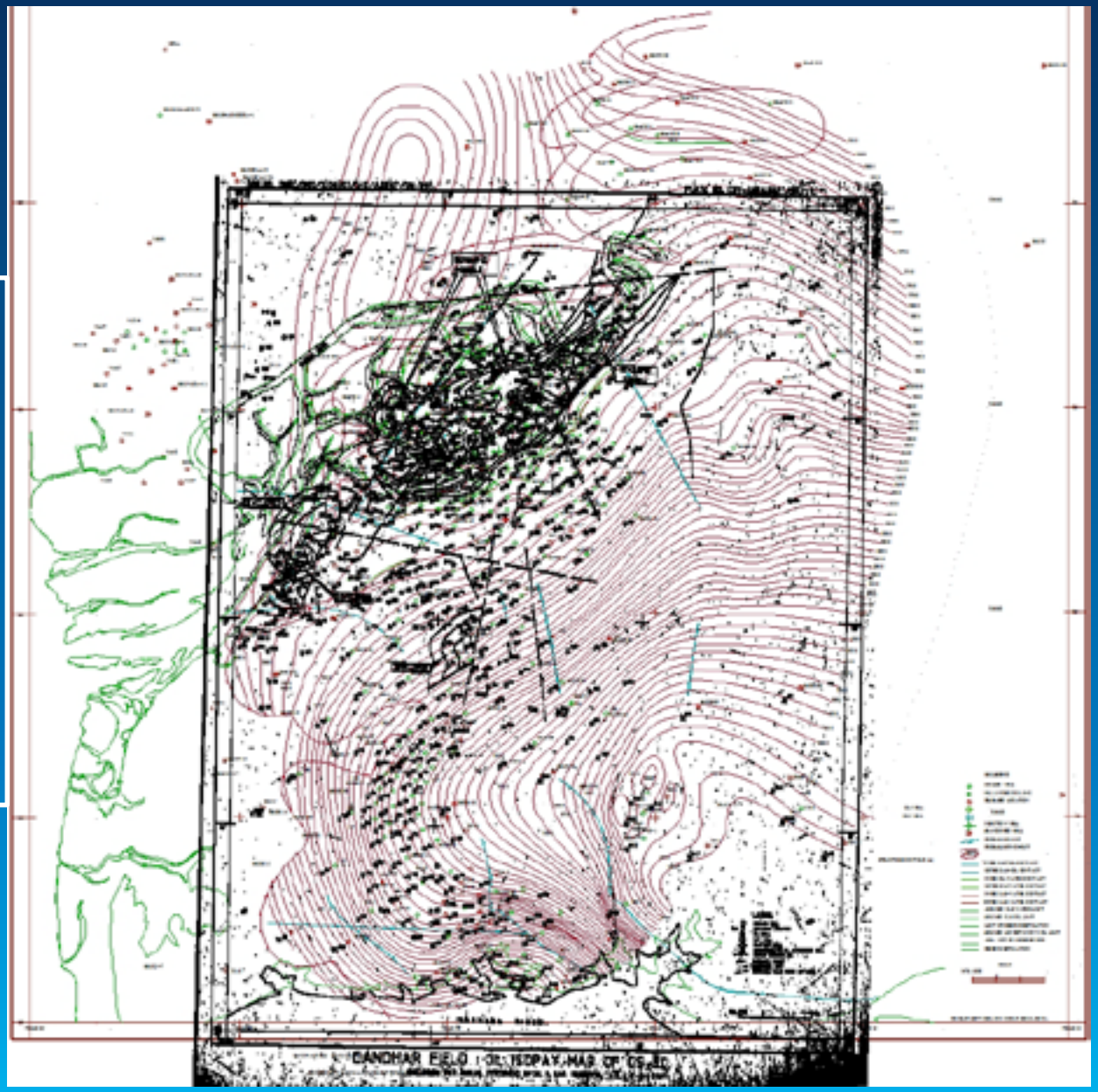
- The stored data (as .shp files) can be very easily retrieved to geological interpretation workstations whenever necessary, for quick decision making

- Superposition of different maps for synergistic study is possible – Gravity Magnetic data on seismic, Reserve estimate on geological interpretation etc.

Superposition of different maps for synergistic study

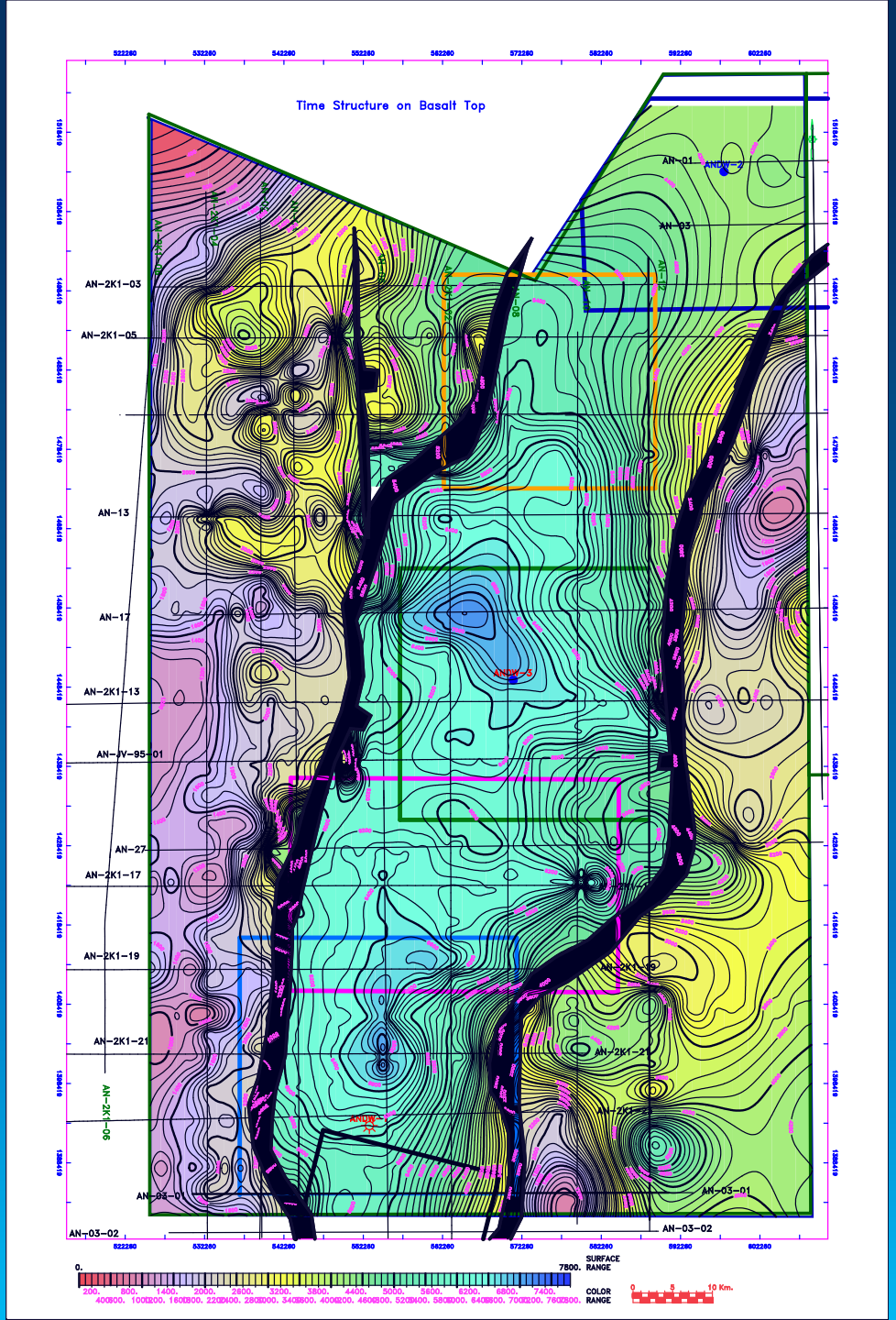
A legacy isopay map of Gandhar area of Western India superposed on a relatively new interpretation map:

Example of a raster map placed on a vector map



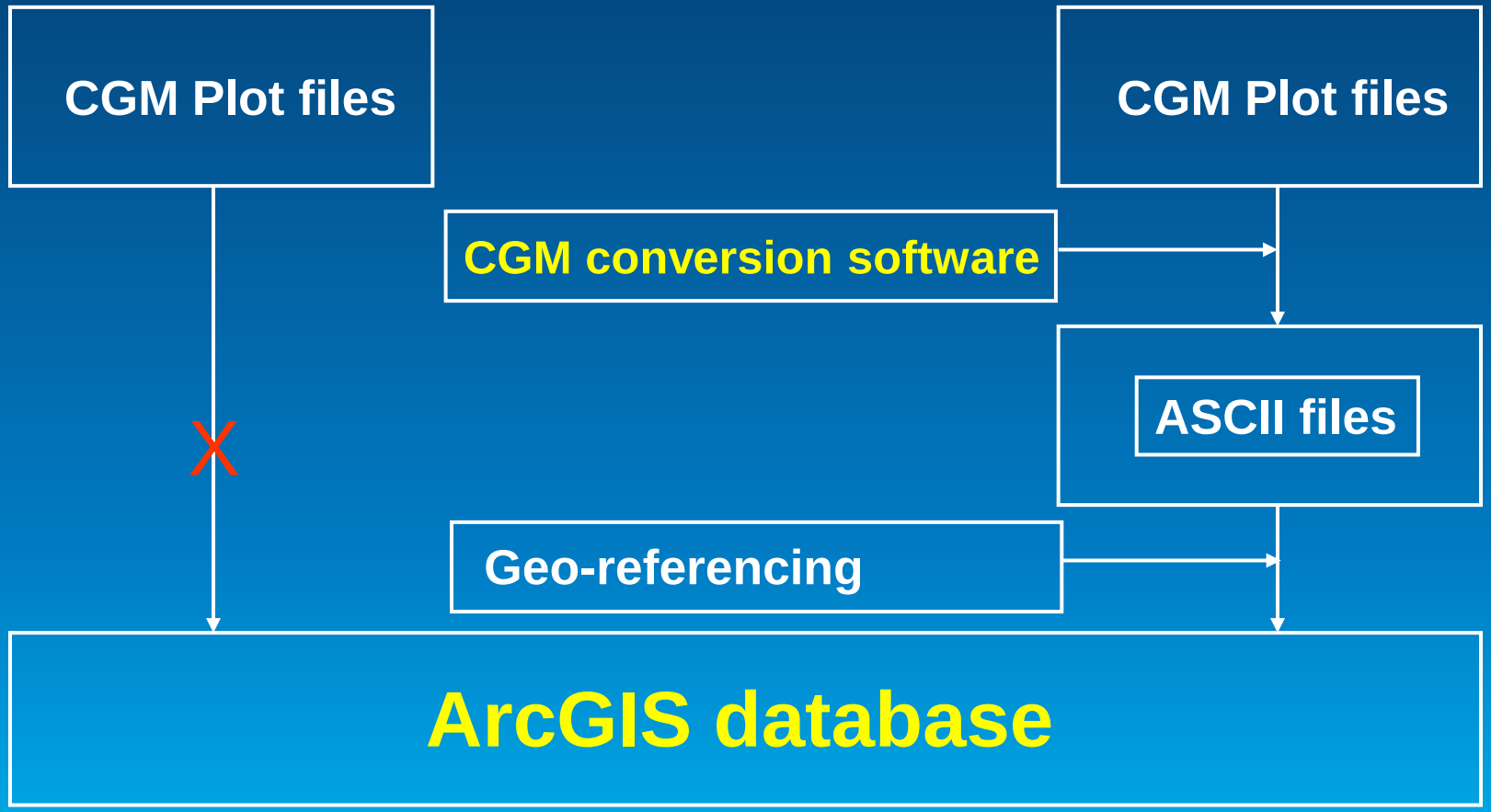
Only a picture

Interpretation map from original CGM file can be displayed with any CGM viewer but cannot be converted to live data

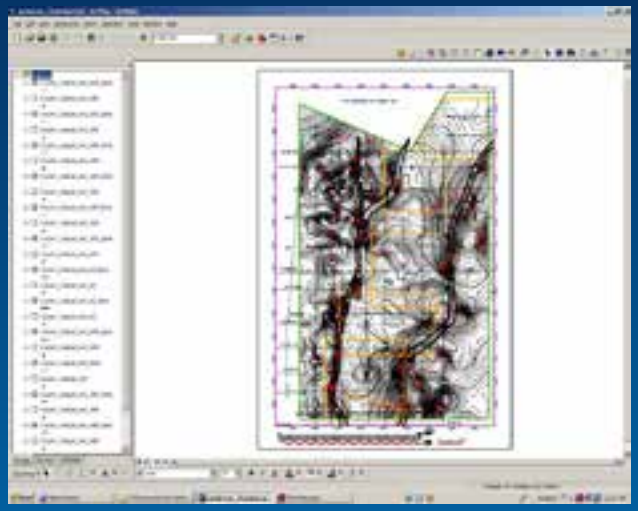


Software integration for breathing life into pictures

Decoding of CGM files is essential for creating a ArcGIS based database of oil E&P maps because …
CGM files cannot be input directly into ArcGIS

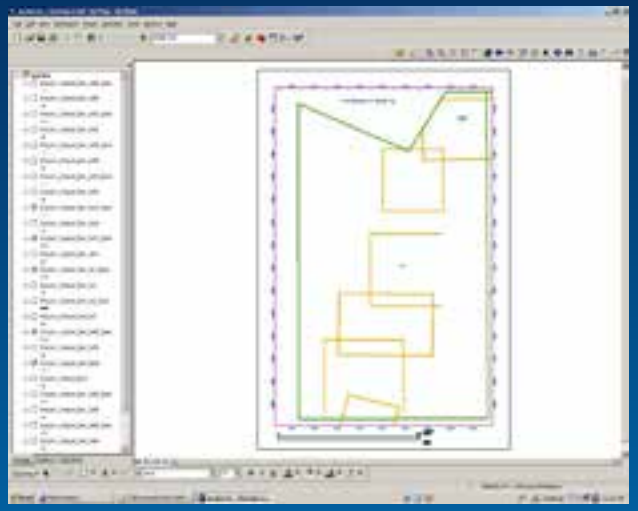


Storing digitized maps in a layered ArcGIS-based database structure



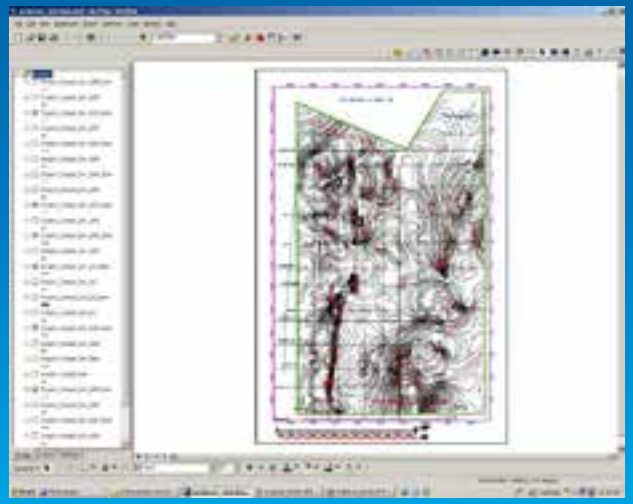
Composite Layer

=



Layer 1: Exploration Block Boundaries

+



Layer 2:Time Contour Map

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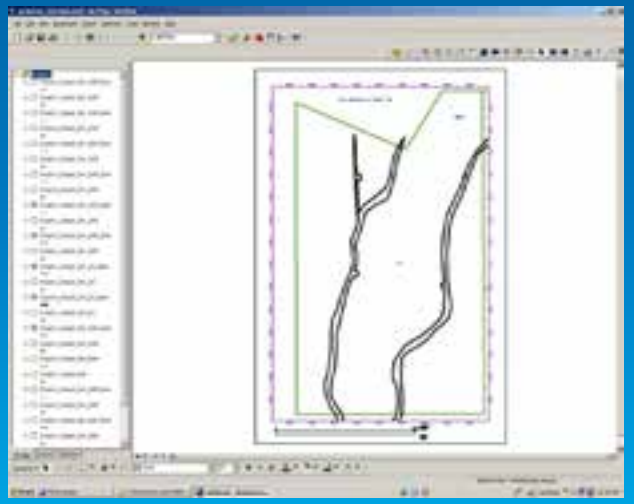


Layer 3: Geological features such as “Faults”

Up-stream Oil & Gas industry produces

Ø Interpretation maps (prior to drilling)

Ø Reservoir estimate maps (before or after drilling)

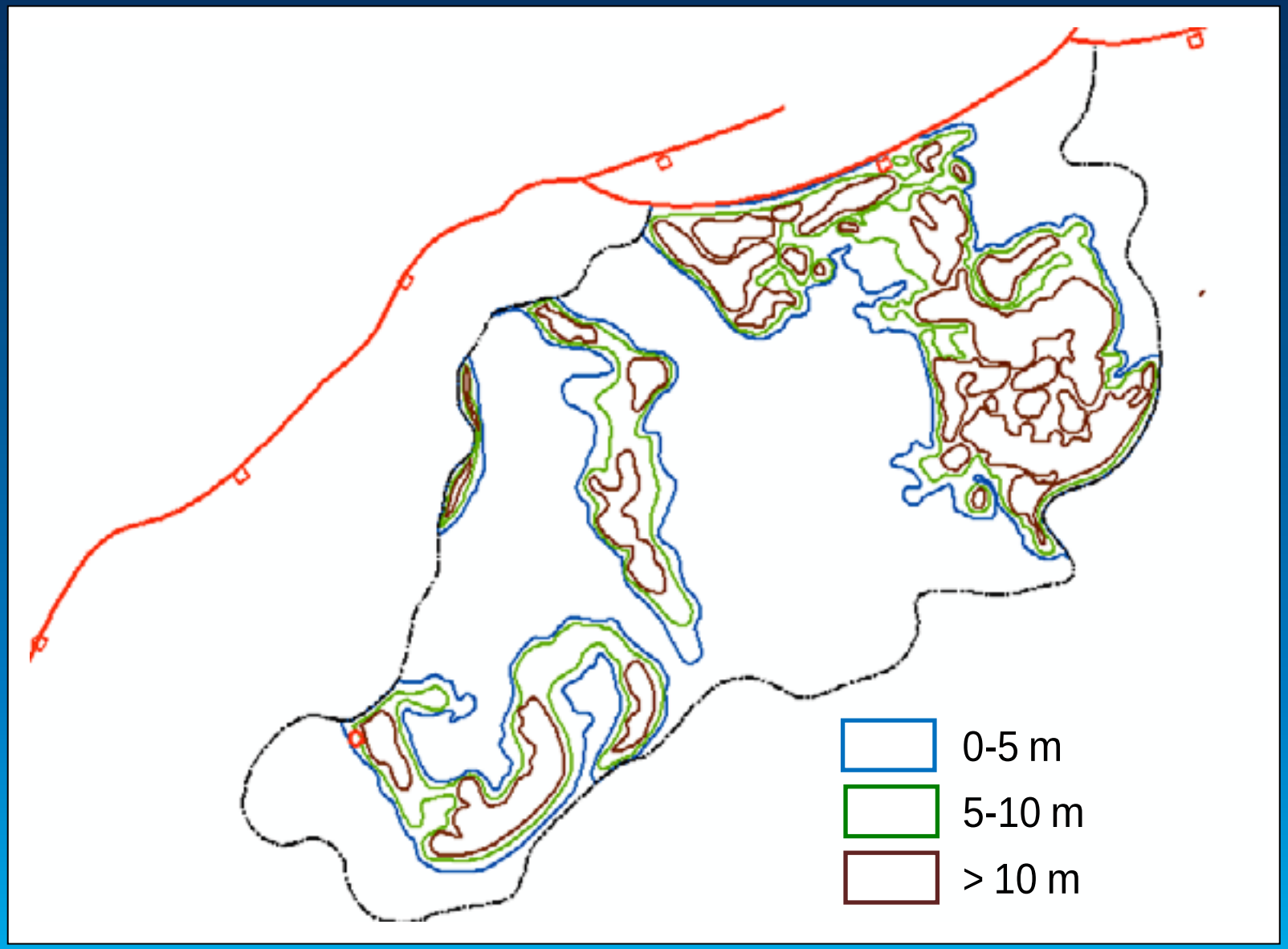
Most of these maps consist of poly-lines and polygons

However, some reserve estimate maps are encoded as

Bezier Curves **in CGM files**

Representations of maps in CGM files as Bezier Curves

Reservoir thickness contour map represented by Bezier Curves



What are Bezier Curves?

A Bézier curve is defined by a set of *control points* $\mathbf{P}_0$ through $\mathbf{P}_n$, where n is called its order (n =1 for linear, 2 for quadratic, etc.).

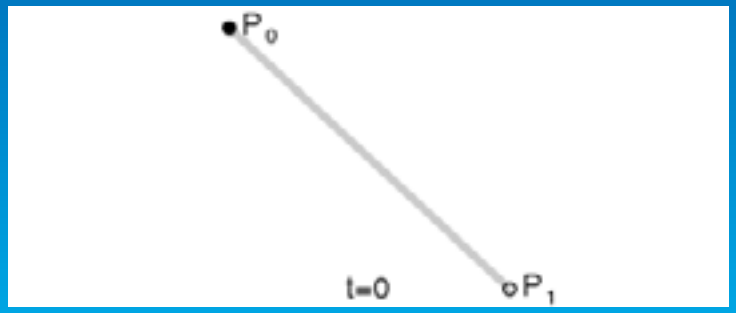
The first and last control points are always the end points of the curve; however, the intermediate control points generally do not lie on the curve.

Linear Bézier curves

Given points $\mathbf{P}_0$ and $\mathbf{P}_1$, a linear Bézier curve is simply a straight line between those two points. The curve is given by

$$\mathbf{B}(t) = \mathbf{P}_0 + t(\mathbf{P}_1 - \mathbf{P}_0) = (1-t)\mathbf{P}_0 + t\mathbf{P}_1\,, \qquad t \in [0,1]$$

and is equivalent to linear interpolation.



Quadratic Bézier curves

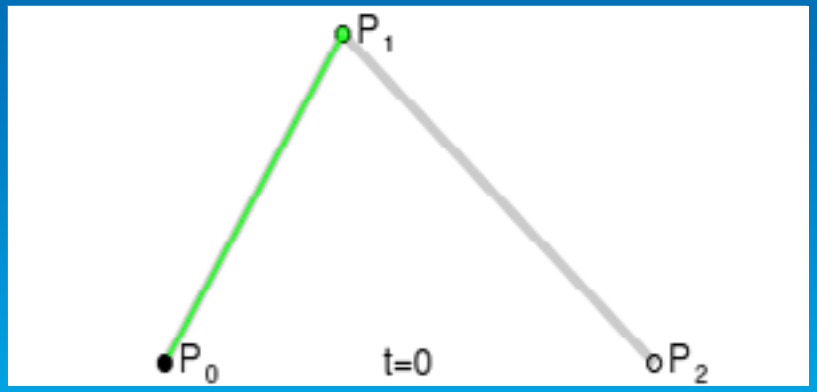
A quadratic Bézier curve is the path traced by the function **B**(*t*), given points $\mathbf{P}_0$, $\mathbf{P}_1$, and $\mathbf{P}_2$

$$\mathbf{B}(t) = (1-t)[(1-t)\mathbf{P_0} + t\mathbf{P_1}] + t[(1-t)\mathbf{P_1} + t\mathbf{P_2}]$$

which can be interpreted as the linear inter-polant of corresponding points on the linear Bézier curves from $\mathbf{P}_0$ to $\mathbf{P}_1$ and from $\mathbf{P}_1$ to $\mathbf{P}_2$ respectively.

Rearranging the preceding equation yields:

$$\mathbf{B}(t) = (1-t)^2\mathbf{P_0} + 2(1-t)t\mathbf{P_1} + t^2\mathbf{P_2}\,, \qquad t \in [0,1]$$



Cubic Bézier curves

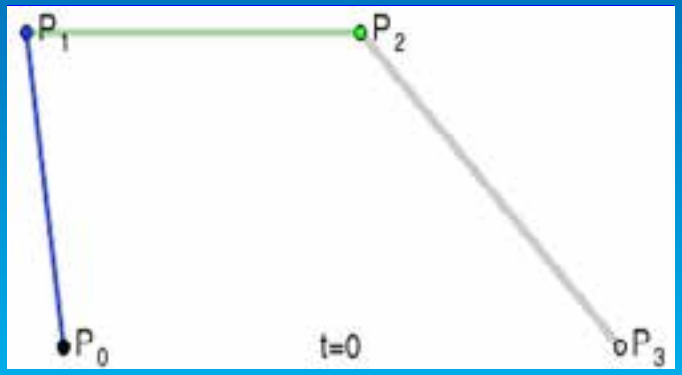
Four points $\mathbf{P}_0$, $\mathbf{P}_1$, $\mathbf{P}_2$ and $\mathbf{P}_3$ in the plane or in higher-dimensional space define a cubic Bézier curve. The curve starts at $\mathbf{P}_0$ going toward $\mathbf{P}_1$ and arrives at $\mathbf{P}_3$ coming from the direction of $\mathbf{P}_2$. Usually, it will not pass through $\mathbf{P}_1$ or $\mathbf{P}_2$; these points are only there to provide directional information.

Writing $\mathbf{B}_{\mathbf{P}_i,\mathbf{P}_j,\mathbf{P}_k}(t)$ for the quadratic Bézier curve defined by points $\mathbf{P}_i$, $\mathbf{P}_j$, and $\mathbf{P}_k$, the cubic Bézier curve can be defined as a linear combination of two quadratic Bézier curves:

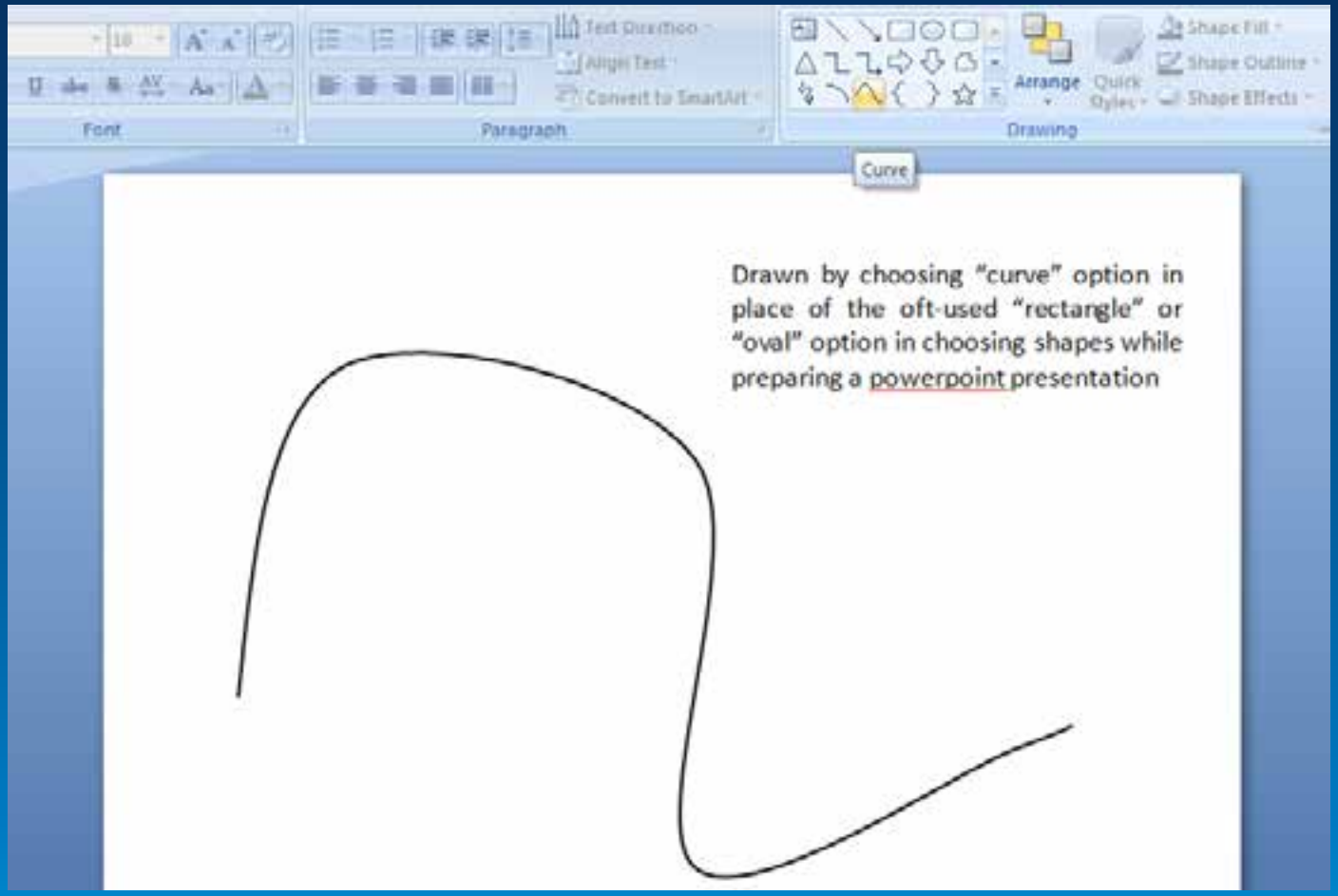
$$\mathbf{B}(t) = (1-t)\mathbf{B}_{\mathbf{P_0},\mathbf{P_1},\mathbf{P_2}} + t\mathbf{B}_{\mathbf{P_1},\mathbf{P_2},\mathbf{P_3}}, \; t \in [0,1].$$

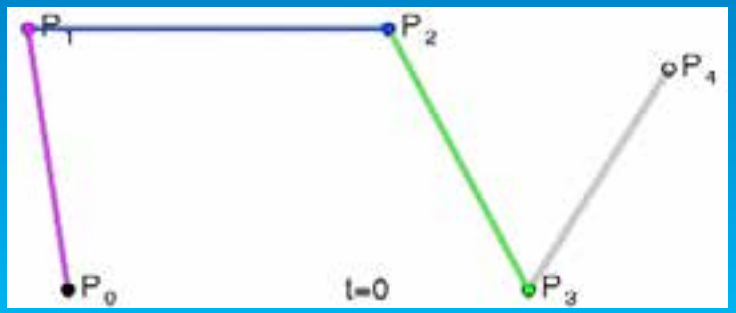
The explicit form of the curve is:

$$\mathbf{B}(t) = (1-t)^3\mathbf{P_0} + 3(1-t)^2 t\mathbf{P_1} + 3(1-t)t^2\mathbf{P_2} + t^3\mathbf{P_3}$$

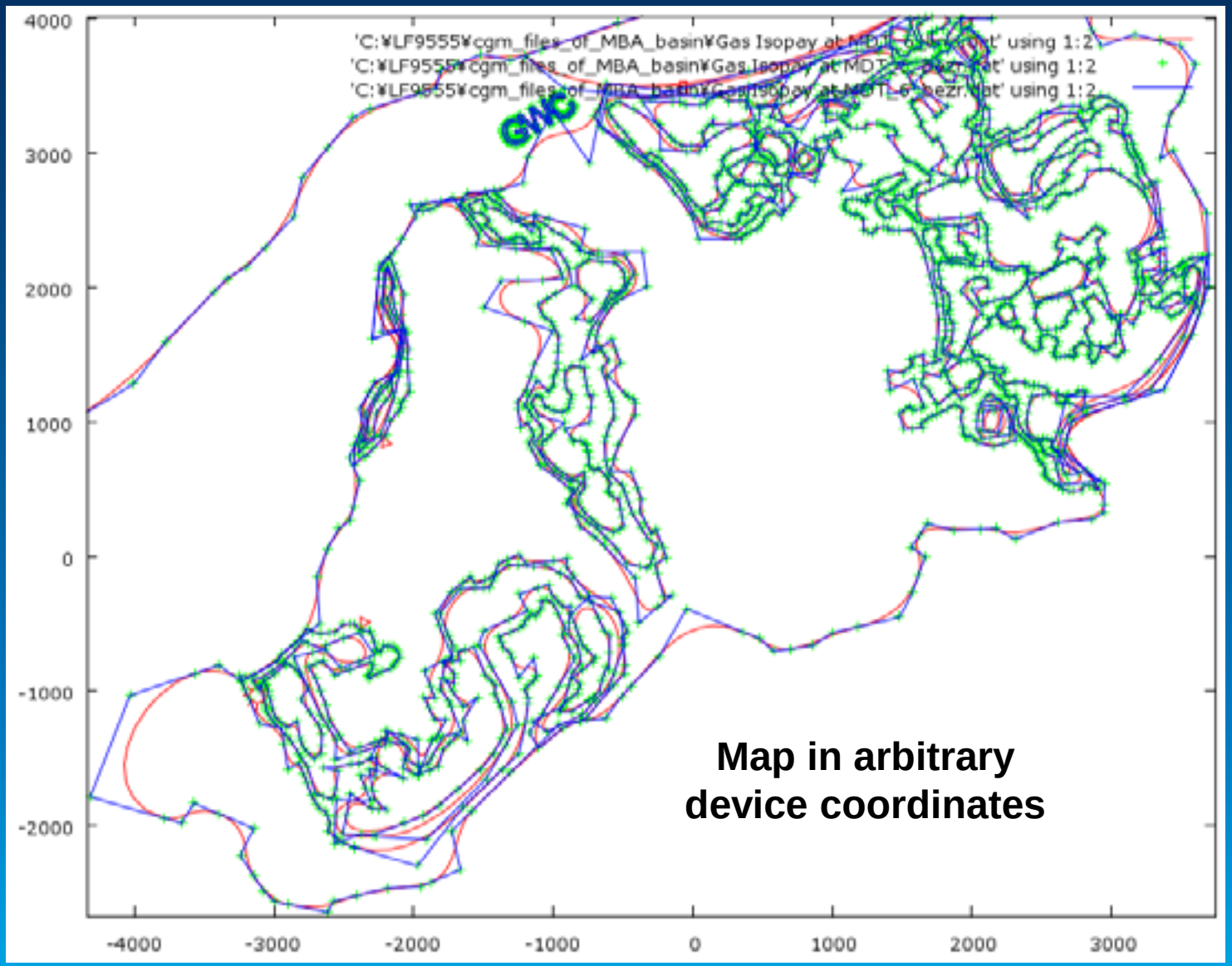


Revisit PowerPoint presentation – choose “curve” option in Drawing Tools



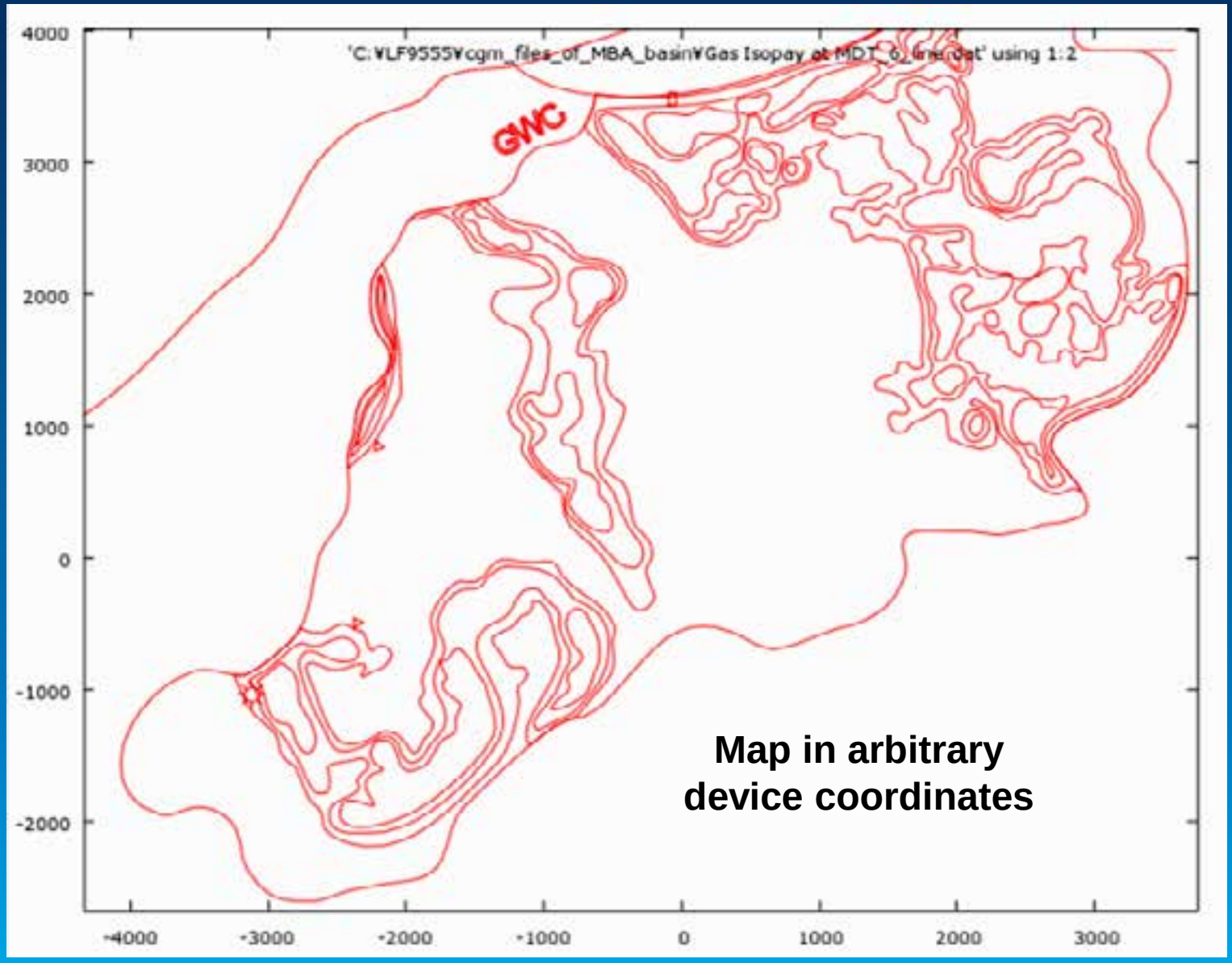


Decoding of CGM file produces map in “device” coordinates

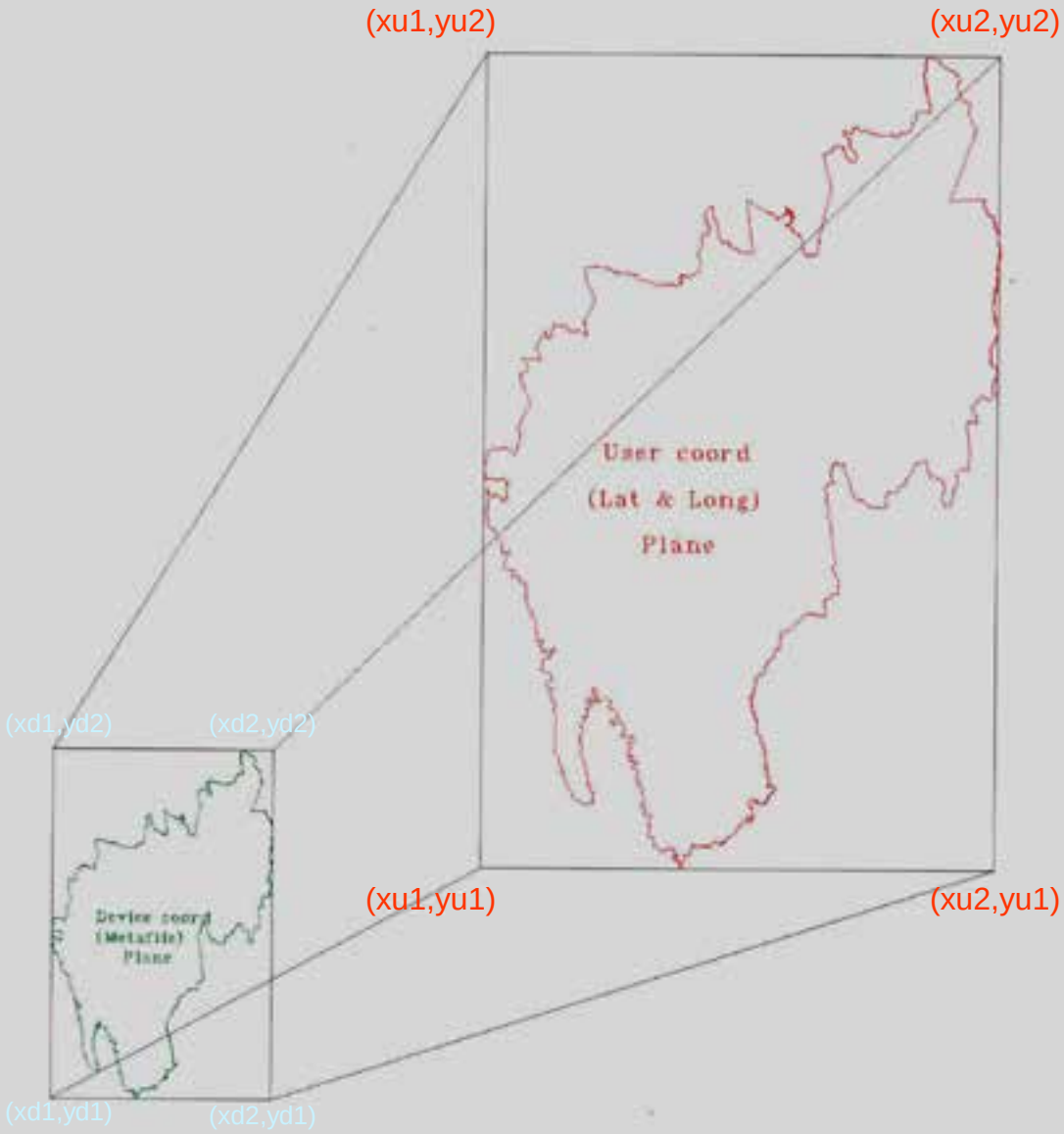


A reservoir thickness map (in red) along with control points joined in blue

Decoding of CGM file produces map in “device” coordinates



After reconstruction of Bezier curves from control points



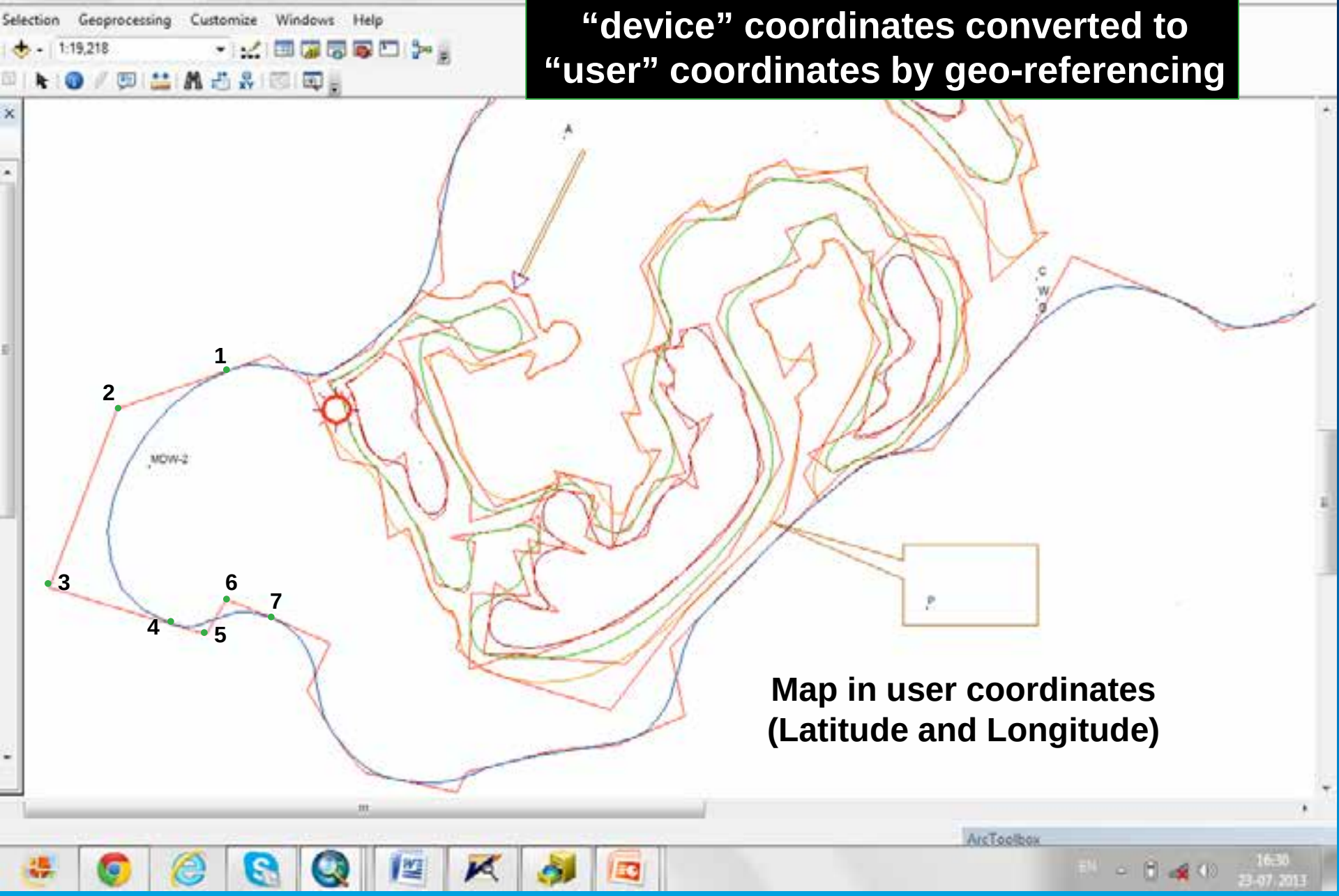
Mapping between device and user coordinates

For isotropic mapping,

$$\frac{yd2 - yd1}{xd2 - xd1} \approx \frac{yu2 - yu1}{xu2 - xu1}$$

(width to height ratio should match closely)

“device” coordinates converted to “user” coordinates by geo-referencing



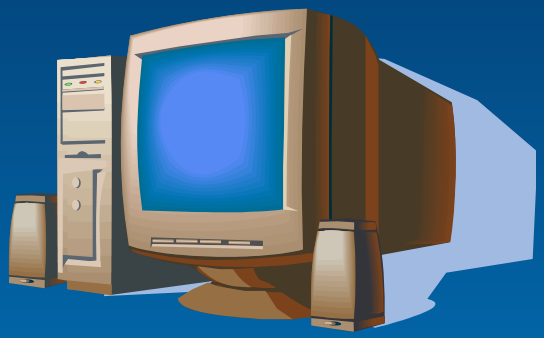
Map in user coordinates (Latitude and Longitude)

Points marked as 1 – 4 and 4 – 7 are **control points** for two adjacent **cubic Bezier curves** joined smoothly at point 4

Important feature of the software

CGM files generated from different workstations have been studied:

- **Landmark**
- **Geoframe**
- **Paradigm**
- **Petrel, Kingdom**



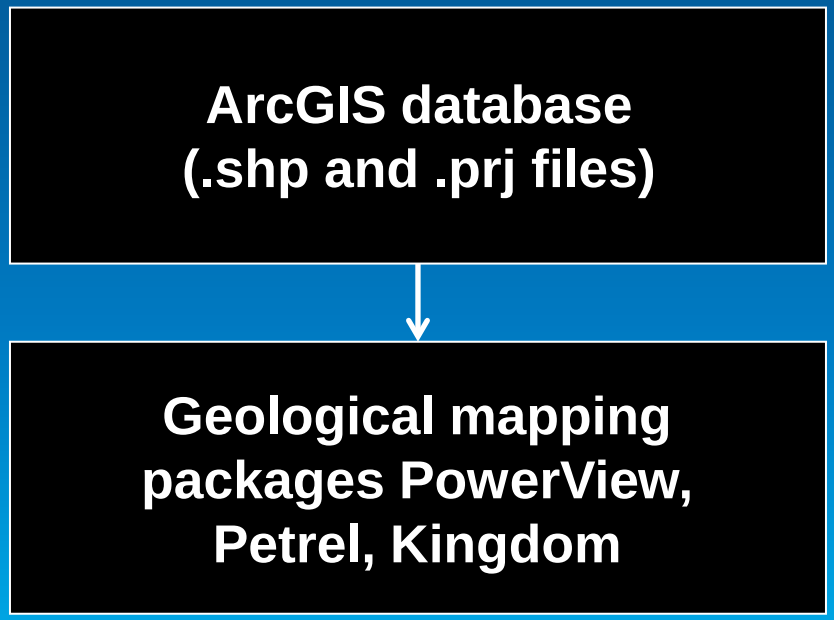
- **Coordinates may be in integer (2, 3 or 4 bytes) or floating point**
- **Numbers are represented as line elements in most cases and as text in some cases like Paradigm, Petrel, CorelDraw**

- **The module *decode_cgmfile* automatically detects all these**

Big advantages of creating database in ArcGIS is

(1) Layered structure of different features of a map

(2) Any required data as .shp (shape) file may be retrieved very quickly onto new generation geological packages such as R5000 PowerView, Petrel, Kingdom

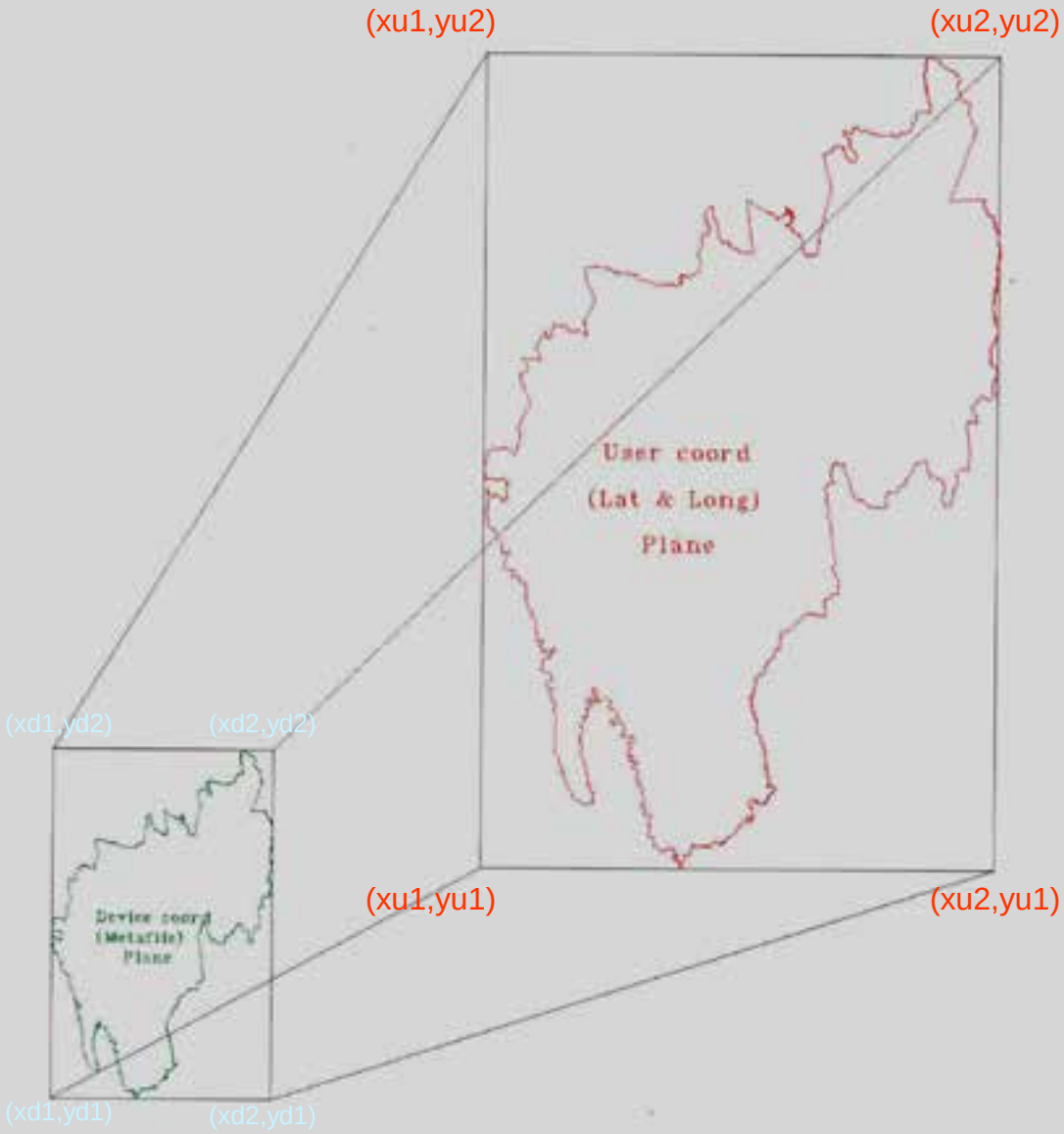


Device Coordinates

0	0	1	1	1	1	5	
8674	0	1	1	1	1	5	
8674	13956	1	1	1	1	5	← Outer rectangle
0	13956	1	1	1	1	5	
0	0	1	1	1	1	5	
400	13556	2	1	2	47	5	
8274	13556	2	1	2	47	5	
8274	800	2	1	2	47	5	← Inner rectangle
400	800	2	1	2	47	5	
400	13556	2	1	2	47	5	
8274	880	3	1	1	48	2	
8274	800	3	1	1	48	2	
7487	880	4	1	1	48	2	
7487	800	4	1	1	48	2	
7366	696	5	1	1	48	3	
7392	696	5	1	1	48	3	
7373	656	5	1	1	48	3	
7366	696	6	1	1	48	3	
7366	694	6	1	1	48	3	
7390	694	6	1	1	48	3	
7390	696	7	1	1	48	3	
7371	656	7	1	1	48	3	
7373	656	7	1	1	48	3	

Col 1 : x coordinate
Col 2 : y coordinate
Col 3 : Segment No.
Col 4 : Line type
Col 5 : Line width
Col 6 : Line colour
Col 7 : No. of points in each segment

Other line segments



Mapping between device and user coordinates

For isotropic mapping,

$$\frac{yd2 - yd1}{xd2 - xd1} \approx \frac{yu2 - yu1}{xu2 - xu1}$$

(width to height ratio should match closely)

User Coordinates

662460	2069920	1	1	1	1	5
717540	2069920	1	1	1	1	5
717540	2158540	1	1	1	1	5
662460	2158540	1	1	1	1	5
662460	2069920	1	1	1	1	5
665000	2156000	2	1	2	47	5
715000	2156000	2	1	2	47	5
715000	2075000	2	1	2	47	5
665000	2075000	2	1	2	47	5
665000	2156000	2	1	2	47	5
715000	2075508	3	1	1	48	2
715000	2075000	3	1	1	48	2
710003	2075508	4	1	1	48	2
710003	2075000	4	1	1	48	2
709234	2074340	5	1	1	48	3
709399	2074340	5	1	1	48	3
709279	2074086	5	1	1	48	3
709234	2074340	6	1	1	48	3
709234	2074327	6	1	1	48	3
709387	2074327	6	1	1	48	3
709387	2074340	7	1	1	48	3
709266	2074086	7	1	1	48	3
709279	2074086	7	1	1	48	3

← Outer rectangle

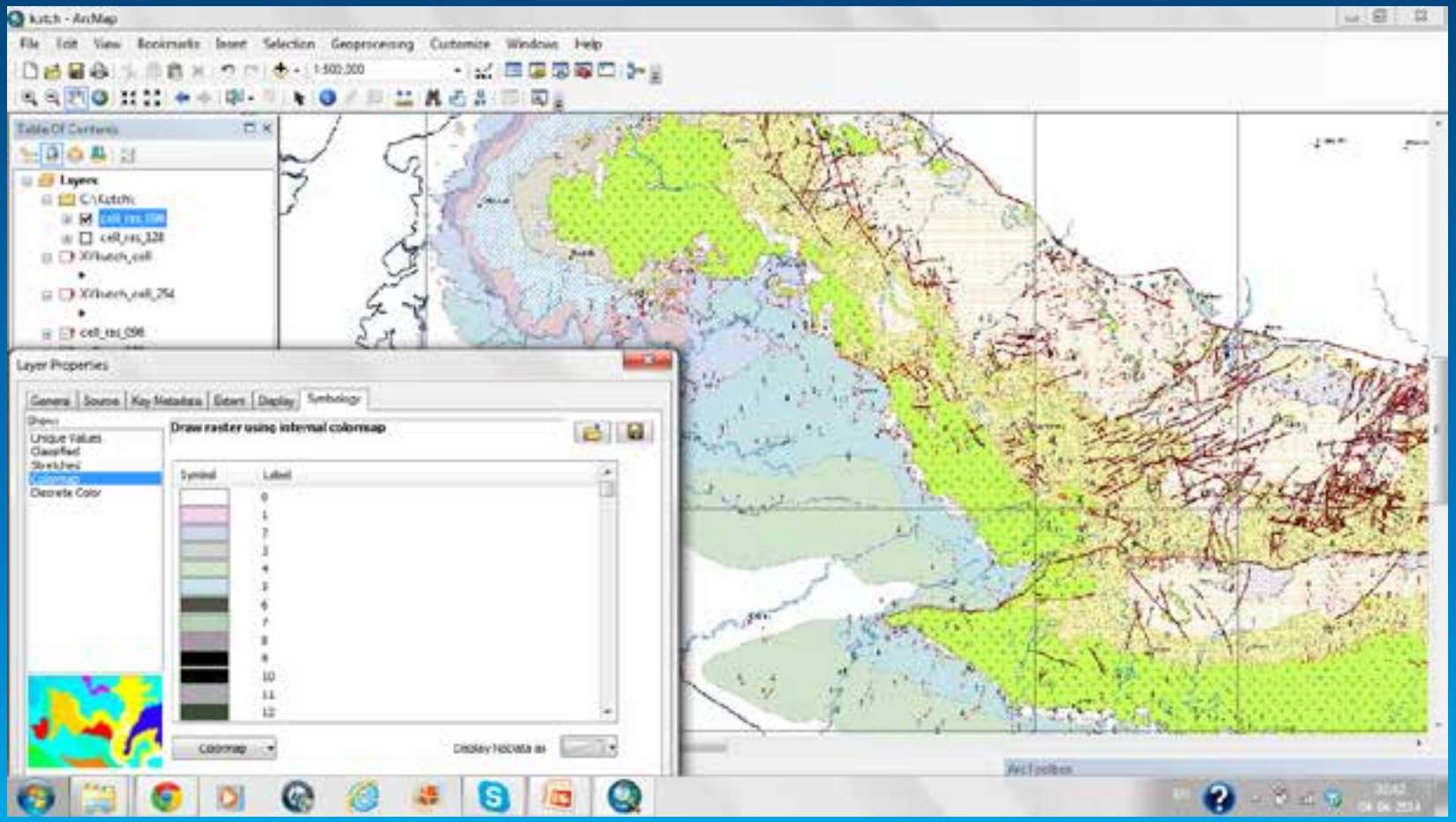
← Inner rectangle

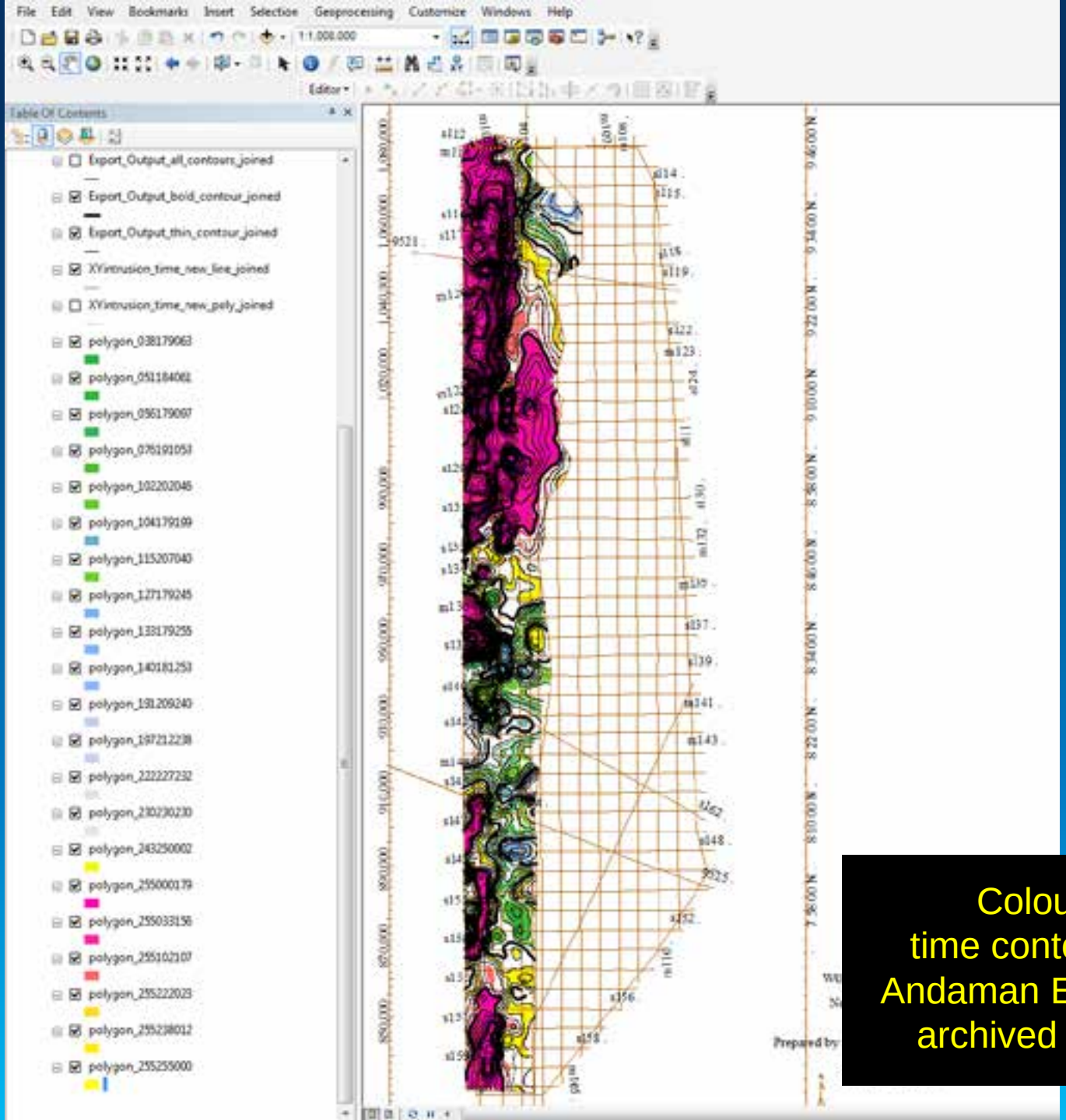
Other line segments

Col 1 : x coordinate
Col 2 : y coordinate
Col 3 : Segment No.
Col 4 : Line type
Col 5 : Line width
Col 6 : Line colour
Col 7 : No. of points in each segment

Other important feature of the software

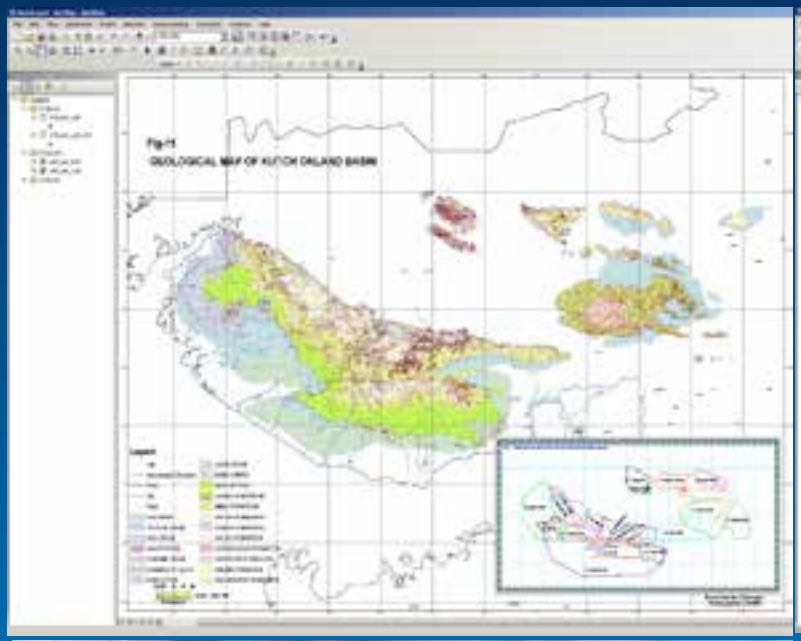
The third party software also generates a color table from the CGM file that can be imported into ArcGIS so that the original colors of the map may be exactly reproduced *in one go*

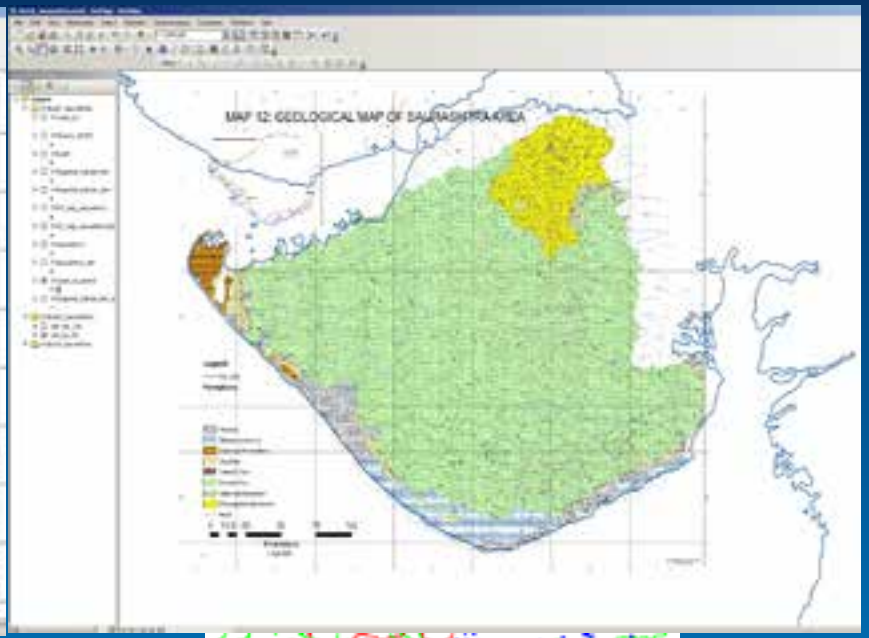


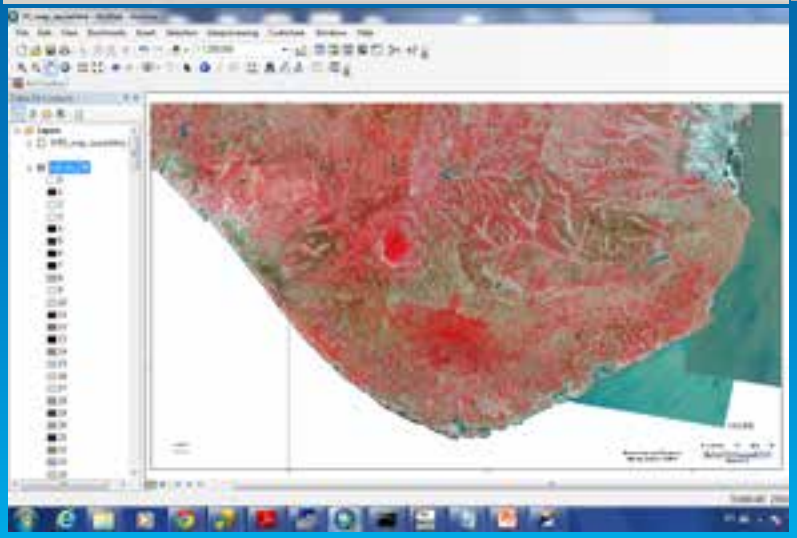


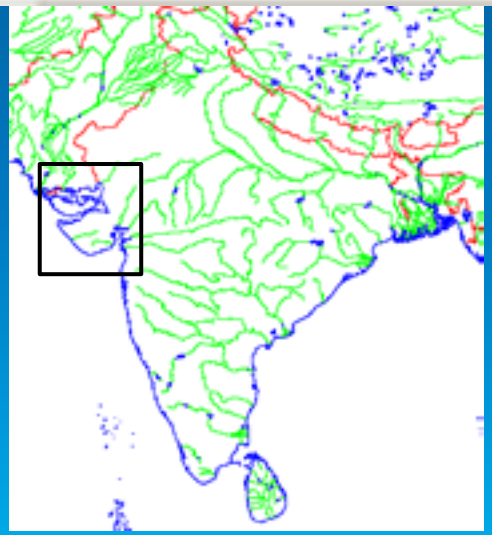
Colour filled
time contour map of
Andaman East offshore
archived in **ArcGIS**

Data integration of raster (geological & remote sensing) and vector (Indian coastline) data from different sources

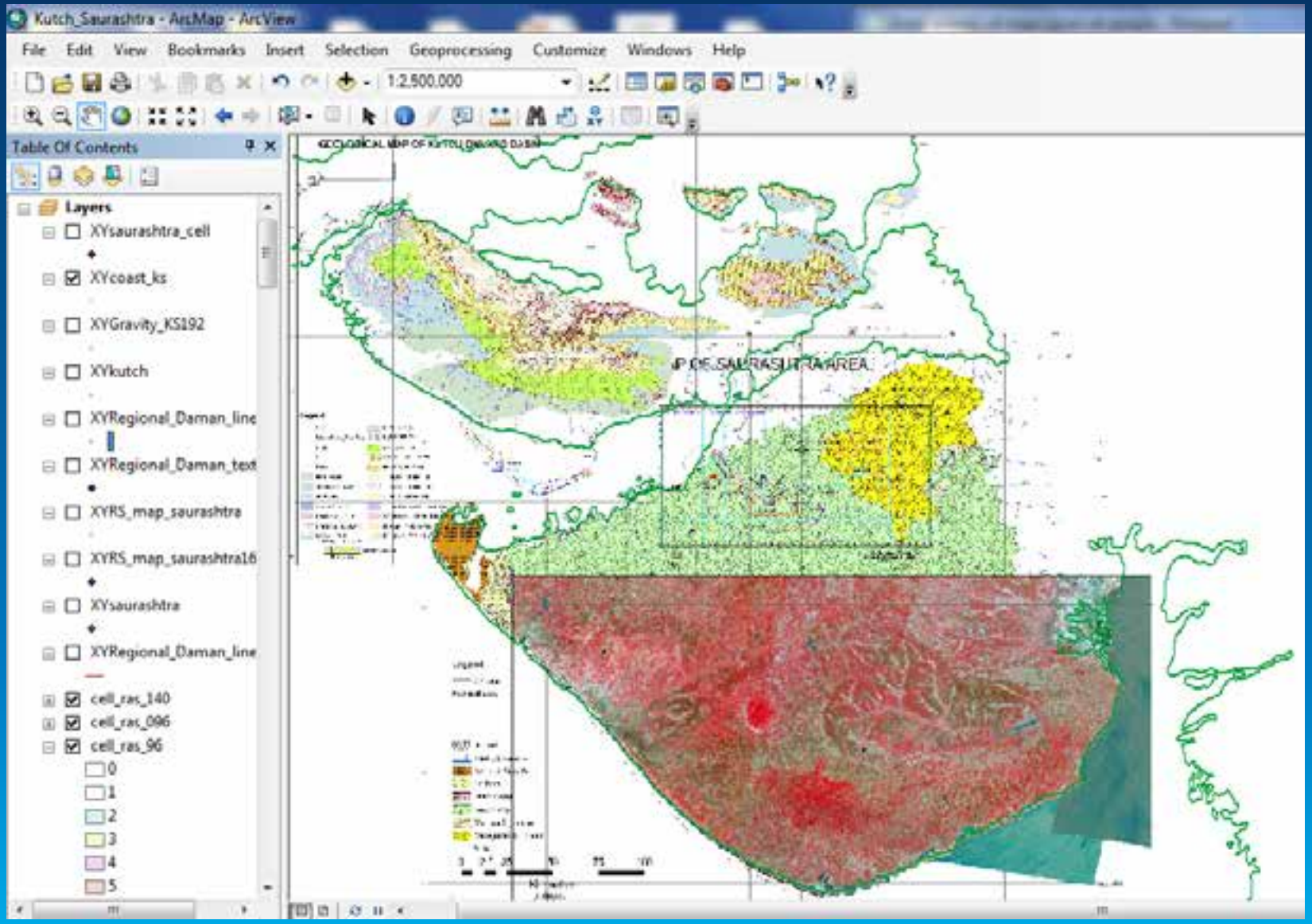






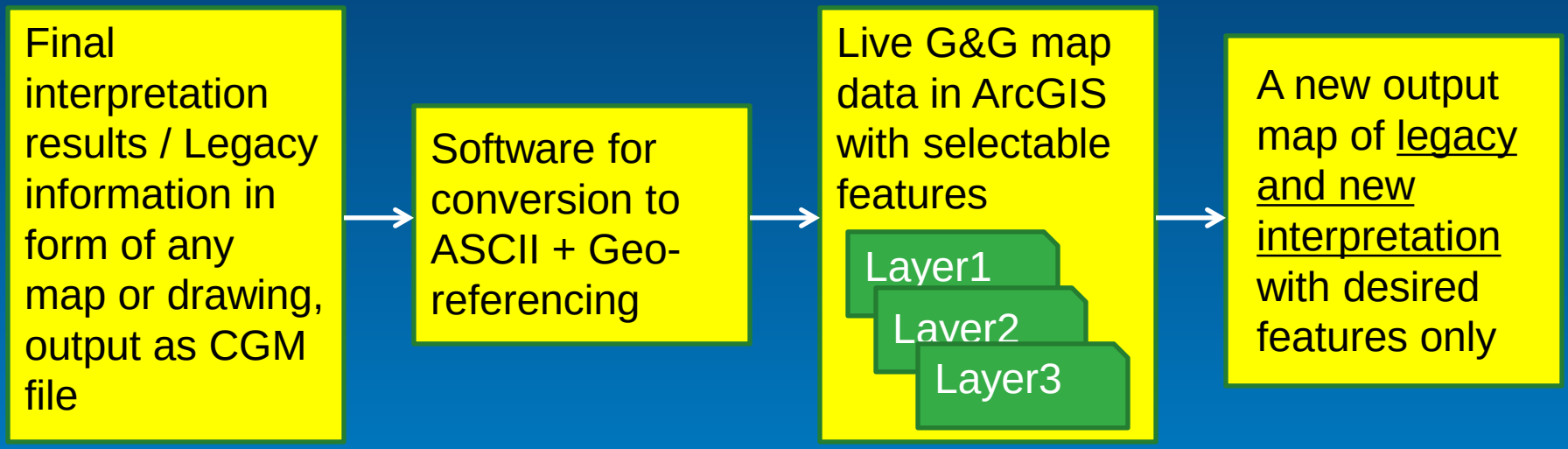


Data integration of raster (geological & remote sensing) and vector (Indian coastline) data from different sources



Summary

A methodology has been devised to import the contents of Geological time/depth or reserve estimate maps of oil E&P companies into the ArcGIS database



Ø To complete the cycle, the “Shape files” stored in ArcGIS database can be quickly imported back to interpretation workstations whenever an old project needs to be loaded

Acknowledgement

- Basin Manager, ONGC, Kolkata, India
- DS Mitra, GM(Geol) and his group at Remote Sensing and Geomatics Lab, Dehradun, ONGC
- Colleagues at Kolkata work-center of ONGC, India

Thank you

for

your kind attention