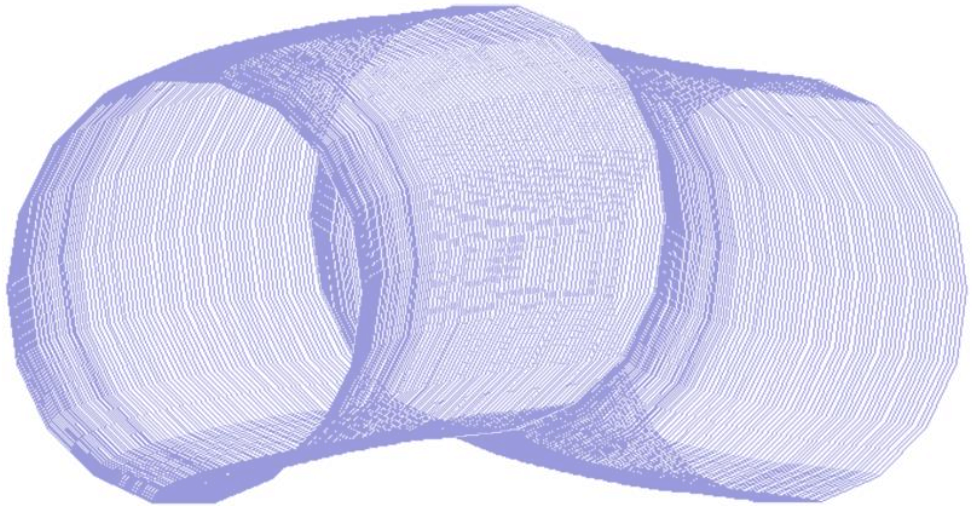
The general consensus

- Assessing tortuosity is important
- An agreed standard formula would be helpful
- Must be simple to implement and explain
- Must be 3D to take account of high/low left/right variation
- For a standard to be established, agreement trumps perfection



A simple 3D approach

Add up Total Vertical Curvature and Divide by 90°

Add up Total Lateral Curvature and Divide by 90°

Tortuosity Index = sqrt(TVC/90 ^2 + TLC/90 ^2)

Dividing by 90

equates the TI to the

number of right

angles accumulated

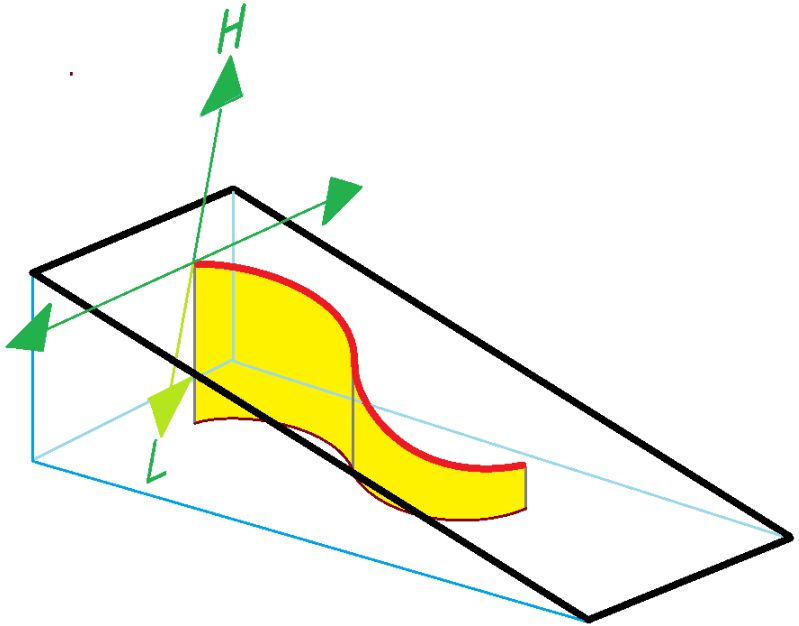
These common profiles

would all have a perfect TI of 1

Perpendicular components of dogleg

- If the high side component is the build or drop…
- The lateral component is the ‘Effective Turn’.

Effective Turn is the dogleg
in the lateral plane across the well bore.
This is NOT the azimuth change
at inclinations other than horizontal



- Effective Turn = Turn x sin(Inclination)

Accumulating Vertical and lateral curvature

1. For each survey interval find the Build Angle

Change in Inclination = dInc = Inc – prev inc

2.Find the Effective Turn Angle

Change in Direction = dDir = Dir – prev Dir

if absolute value dDir > 180 then dDir = dDir - 360 * sign(dDir) (shortest way round)

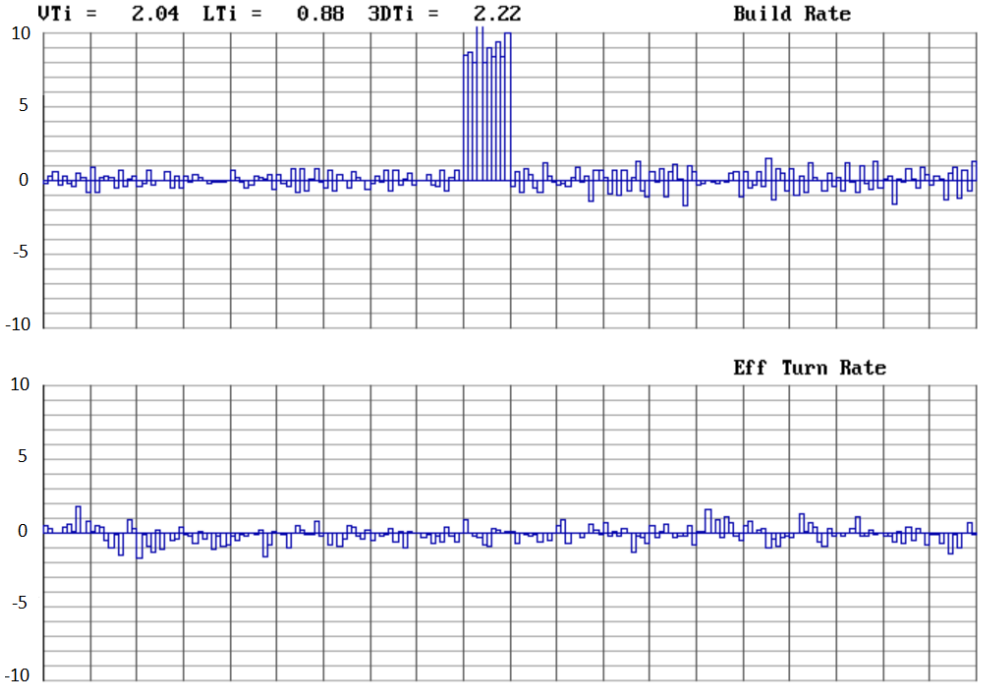
Effective Turn = dDir * sin(inclination) (use final inclination in the interval)

3. Accumulate absolute values of dInc to find Total Vertical Curvature TVC

4. Accumulate absolute values of Effective Turn to find Total Lateral Curvature TLC

5. For convenience, plot the rates (multiply by 100 / Md change (or 30/Md change for metres))

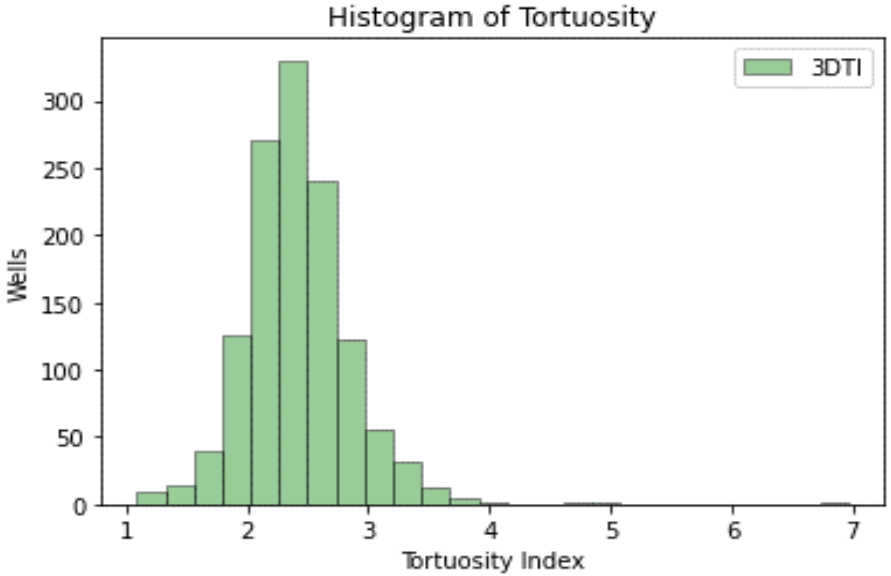
Build rate and ET Rate (shown in Degs/100ft)



Calculating a 3d tortuosity index

- **Calculate TVC and TLC for the well**
- **Calculate Vertical Tortuosity Index**
- **VTI = TVC / 90**
- **Calculate Lateral Tortuosity Index**
- **LTI = TLC / 90**
- **Calculate 3DTI**

$$3DTI = \sqrt{VTI^2 + LTI^2}$$



Weighted TI

- A second useful number has proved to correlate well with Torque and drag.
- The accumulated curvature for any interval is weighted by how early it occurs in the wellbore.
- Weight = 2 – 2md / td
- This weight has an average of 1