How Human Error In Wellbore Placement Can Adversely Affect Your Bottom Line

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Poll Question

How many years of experience do you have in oil and gas?

Poll Question

What is your age range?

Poll Question

What is your primary technical discipline?

Poll Question

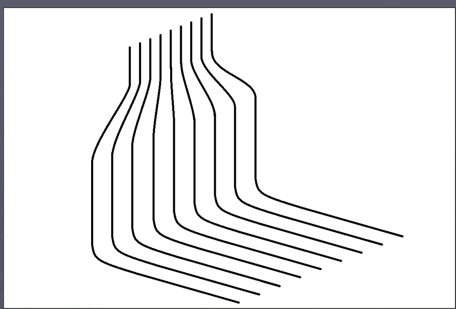
In what way is wellbore positioning important for you?

Don’t be in the wrong place at the wrong time !!

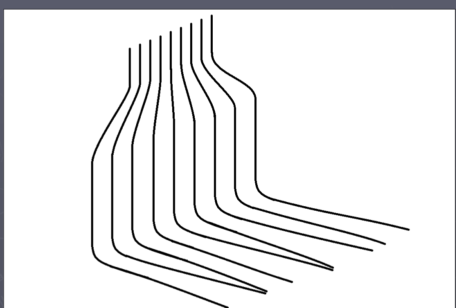
Why do we survey at all ?

- Ensure a safe well path to the target
- Measure the progress and correct the path
- Ensure you hit target & maximise production
- Ensure you don't hit another well
- Provide good log positions to G&G
- Provide good reserves estimates
- Report data to the government
- Conduct 'forensics' investigations afterwards
- To be prepared for a relief well if necessary

Good Surveying = Good Production



Good Surveying = Good Production



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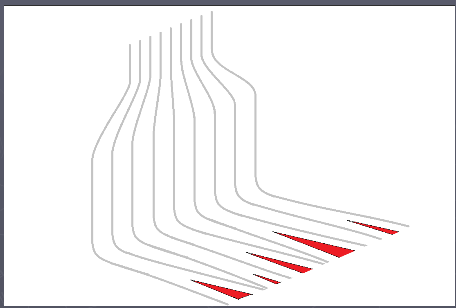

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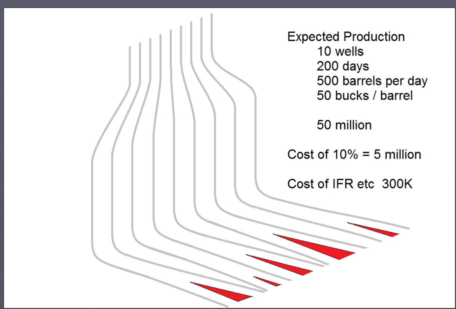

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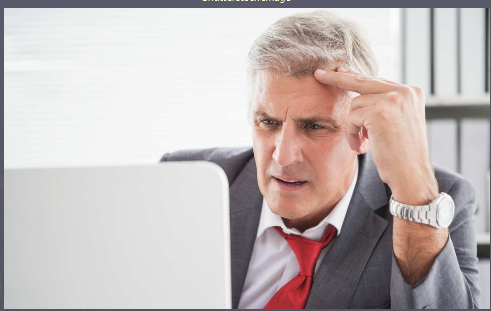
Business Case ?

► A shorter gyro run	$10,000 +
► A proximity 'shut in'	$100,000 +
► A plug back sidetrack	$1 million +
► A dry well or 'Dead Zone'	$10 million +
► A deep landing	$100 million +
► A minor collision blowout	$1 billion +
► A major collision blowout	$10 billion +

What happens if you do collide with another well or geo-hazard ?

Shutterstock Image



Destruction of Assets

image courtesy of John Wright

Environmental Damage

image courtesy of John Wright

Atmospheric Pollution

image courtesy of John Wright

Marine Pollution

image courtesy of John Wright

Reputational Damage

image courtesy of John Wright

Danger to Life

image courtesy of John Wright

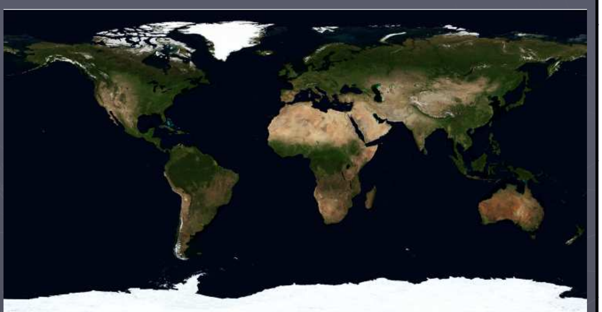
In Summary

Saving money
on surveying is a high stakes gamble which,
if lost, will make you famous

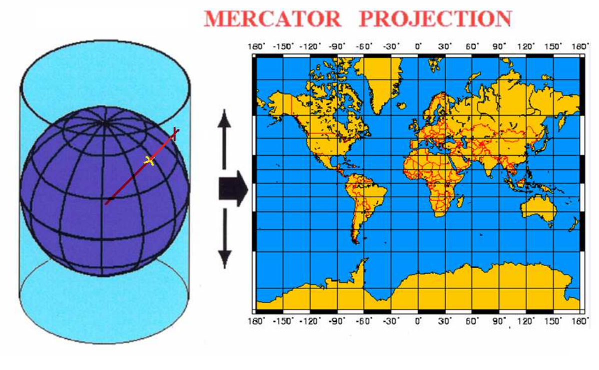
Most Common Reasons for Misplaced Wells

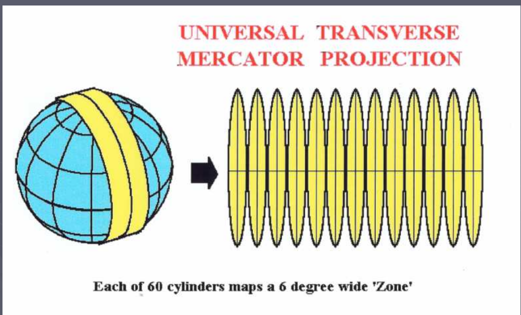
- Misunderstanding the Map System
- Getting the Map Datum Wrong
- Misunderstanding where North Is
- Misunderstanding the Uncertainties
- Failure to use available corrections
- Bad Computer Data unchallenged

Any Projection distorts the World

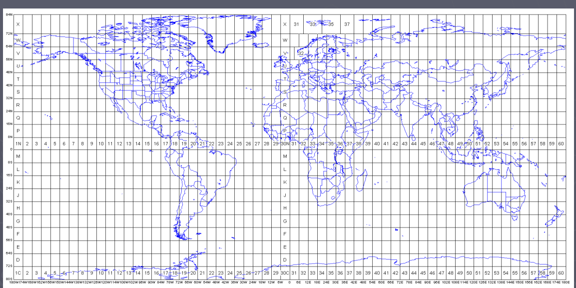


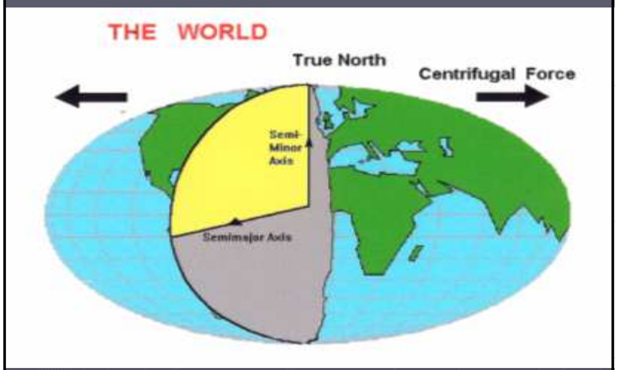
Project from the centre of the Earth



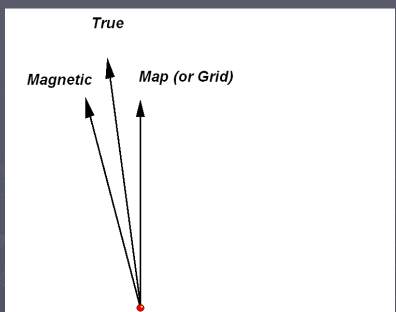


UTM Zones

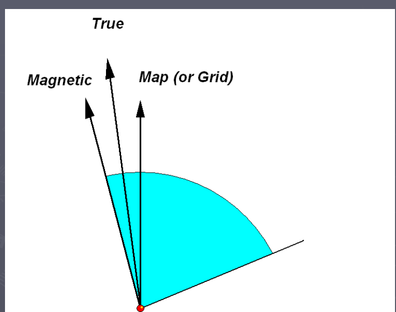




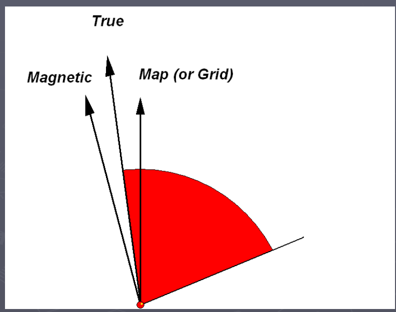
With three Norths it is easy to get confused



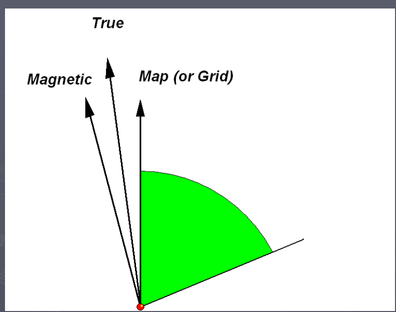
MWD measures from Magnetic North



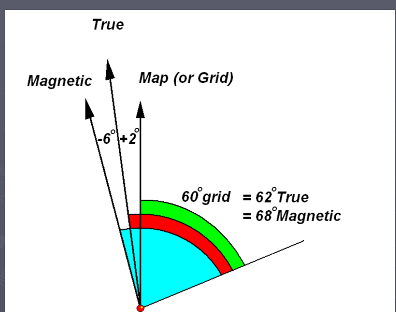
Gyros usually measure from True



But most surveys are finally reported in Grid

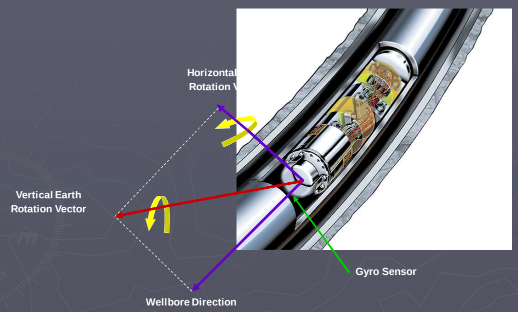


For Example if Declination was -6 degs and Convergence was +2 degs

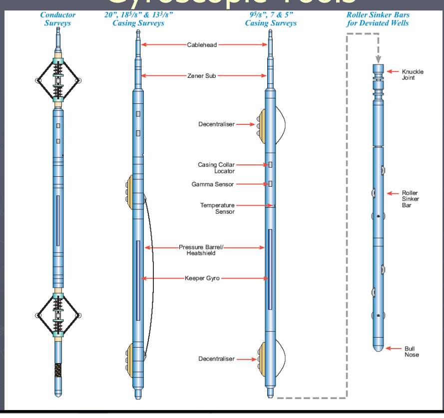


MWD

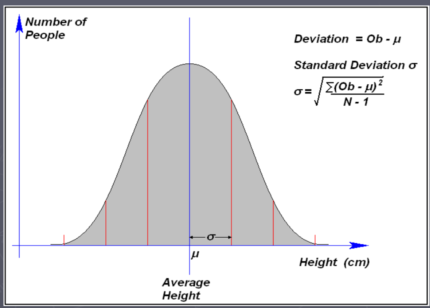
Continuous Gyro



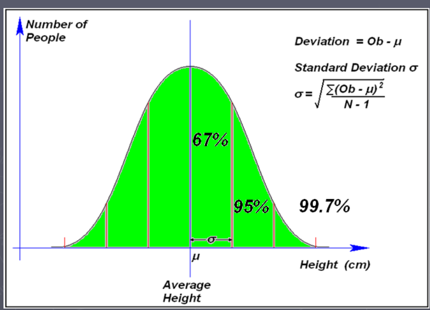
Gyroscopic Tools



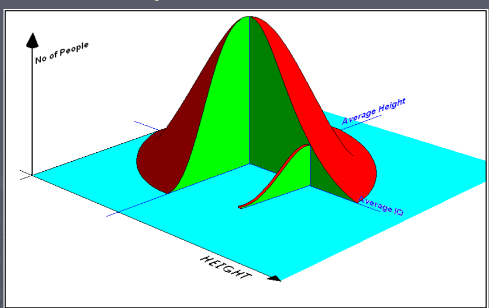
Survey Errors Form A Normal Distribution

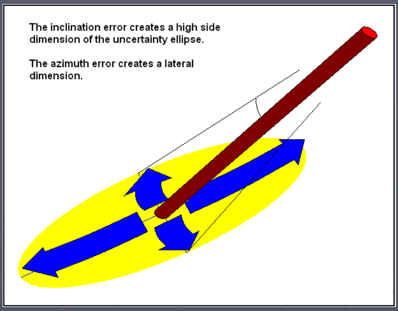


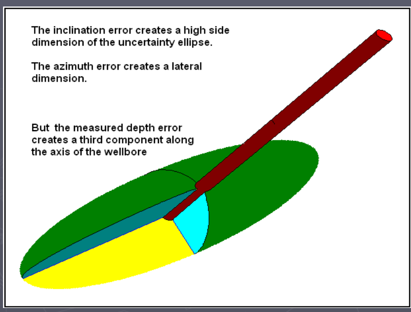
A Normal Distribution



Normal distribution of 2 parameters



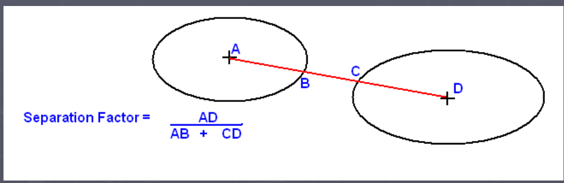




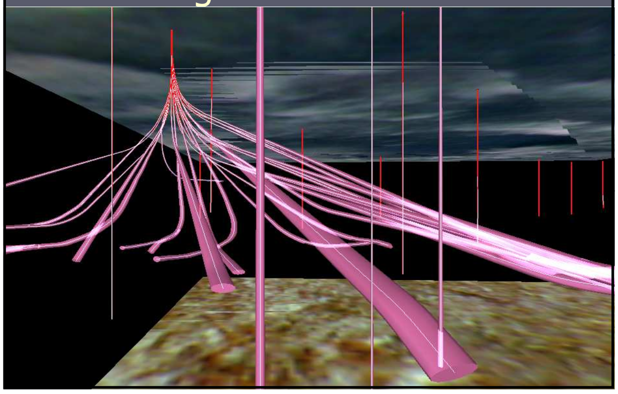
The ISCWSA MWD Model

	Name	Vector	Tie-on	Value (1 sigma)	Units	Formula
1	dref	e	r	0.35000000	m	1.0
2	dsf	e	s	0.00024000	-	tmd
3	dsts	e	s	0.00000022	im	tmd*tvd
4	w_12	n	n	1.00000000	-	sin(inc)
5	w_34	n	n	1.00000000	-	sqrt(1-(w_12)^2)
6	mxy1	i	s	0.06000000	d	w_12
7	mxy2	l	s	0.06000000	d	w_12
8	mxy3	i	s	0.06000000	d	cos(azi)*w_34
9	mxy3	l	s	0.06000000	d	-sin(azi)*w_34
10	mxy4	i	s	0.06000000	d	sin(azi)*w_34
11	mxy4	l	s	0.06000000	d	cos(azi)*w_34
12	sag	i	s	0.20000000	d	(sin(inc))
13	azr	a	g	0.36000000	d	1.0
14	dbh	a	g	5000.00000000	dnt	1.0/(mtot*cos(dip))
15	azm	a	s	0.25000000	d	1.0
16	amid	a	s	0.60000000	d	sin(inc)*sin(azm)
17	abx	i	s	0.00400000	-	(-cos(inc)*sin(tfo))/gtot
18	abx	l	s	0.00400000	-	((cos(inc)*sin(azm)*sin(tfo)-cos(azm)*cos(tfo))*tan(dip)*sin(inc)+cos(tfo)*cos(inc))/
19	aby	i	s	0.00400000	-	(-cos(inc)*cos(tfo))/gtot
20	aby	l	s	0.00400000	-	((cos(inc)*sin(azm)*cos(tfo)+cos(azm)*sin(tfo))*tan(dip)*sin(inc)-sin(tfo)*cos(inc))/
21	abz	i	s	0.00400000	-	(-sin(inc))/gtot
22	abz	a	s	0.00400000	-	(tan(dip)*sin(inc)*sin(azm))/gtot
23	asx	i	s	0.00050000	-	(sin(inc)*cos(inc)*(sin(tfo))^2)
24	asx	a	s	0.00050000	-	(-(tan(dip)*sin(inc)*(cos(inc)*sin(azm)*sin(tfo)-cos(azm)*cos(tfo))+cos(inc)*cos(tfo)
25	asy	i	s	0.00050000	-	(sin(inc)*cos(inc)*(cos(tfo))^2)
26	asy	a	s	0.00050000	-	(-(tan(dip)*sin(inc)*(cos(inc)*sin(azm)*cos(tfo)+cos(azm)*sin(tfo))-cos(inc)*sin(tfo))
27	asz	i	s	0.00050000	-	(-sin(inc)*cos(inc))
28	asz	a	s	0.00050000	-	(tan(dip)*sin(inc)*cos(inc)*sin(azm))
29	mbx	a	s	70.00000000	nt	(cos(azm)*cos(tfo)-cos(inc)*sin(azm)*sin(tfo))/(mtot*cos(dip))
30	mby	a	s	70.00000000	nt	(-(cos(azm)*sin(tfo)+cos(inc)*sin(azm)*cos(tfo)))/(mtot*cos(dip))
31	mbz	a	s	70.00000000	nt	(-sin(inc)*sin(azm))/(mtot*cos(dip))
32	msx	a	s	0.00160000	-	(cos(inc)*cos(azm)*sin(tfo)-tan(dip)*sin(inc)*sin(tfo)+sin(azm)*cos(tfo))*(cos(azm)*
33	msy	a	s	0.00160000	-	(-(cos(inc)*cos(azm)*cos(tfo)-tan(dip)*sin(inc)*cos(tfo)-sin(azm)*sin(tfo))*(cos(azm)
34	msz	a	s	0.00160000	-	(-(sin(inc)*cos(azm)+tan(dip)*cos(inc))*sin(inc)*sin(azm))

Collision Risk



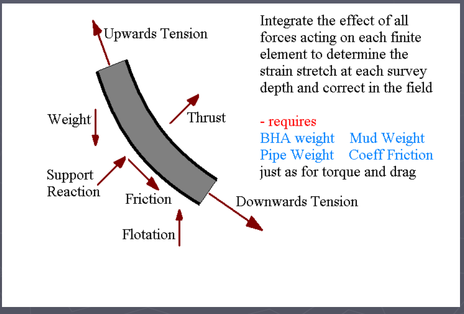
High Collision Risk



Major Corrections to reduce Uncertainty

- Depth Correction
  - There are many sources of error affecting both drill pipe and wireline length downhole but depth correction will usually address the mechanical and thermal stretch. These account for the major depth errors and can be as much as 0.2%
- Sag Correction
  - This is an inclination correction to allow for the natural bending of the BHA under its own weight. It increases with inclination and can be 0.5 degrees or more.
- IFR Correction
  - This usually refers to the local correction of magnetic declination and is derived from an In-Field Referencing survey of the oilfield. This can be up to 1 degree in places
- Magnetic Interference
  - This applies to azimuth only and corrects for the magnetic influence of the BHA itself. It is particularly important when using short non-mag collars.

Mechanical Stretch

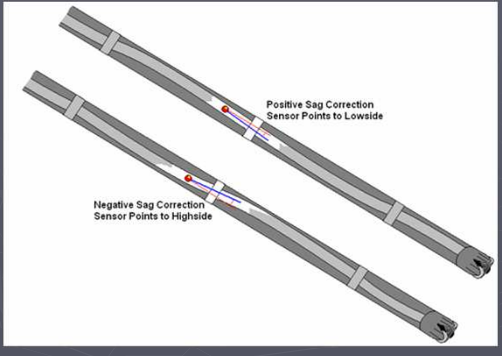


Temperature Effects

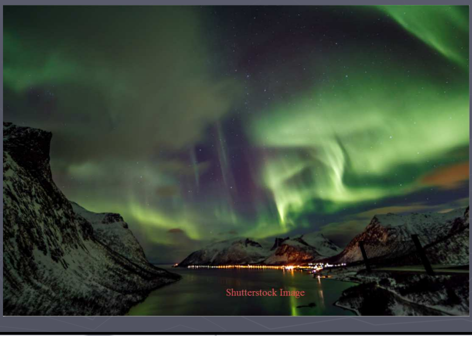
- Steel will stretch by

1.3m / 1000 / 100 degs C

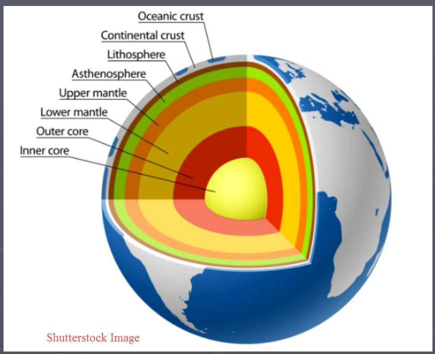
Sag Correction



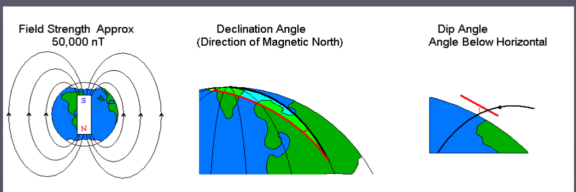
MWD Relies on the Earths Magnetic Field



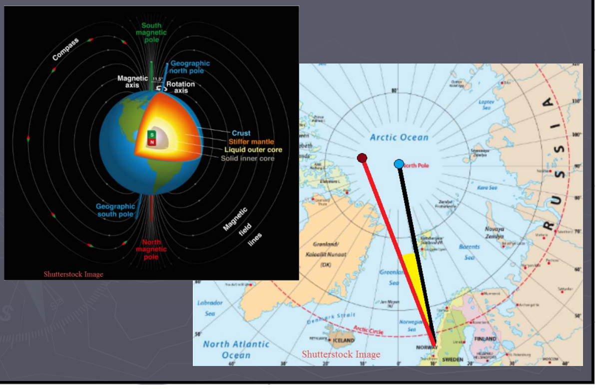
The Earth Has a Magnetic Core



The Earth's Magnetic Vector



Declination

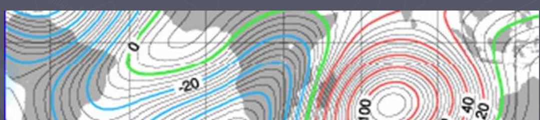


A Powerful Force but subject to three Variations

1. Secular Variation
   Long slow changes in the earths magnetic core.
   Typical Size: Fractions of a deg/year
   Cured By: BGGM model
2. Diurnal Variation
   Rapid daily variations caused by solar wind and earth rotation
   Typical Size: 0.2 degs (Randomized)
   Cured By: Interpolated In Field Referencing (IIFR)
3. Crustal Variation
   Permanent local effects caused by deep, magnetic basement rock
   Typical Size: 1 degree
   Cured By: In Field Referencing (described later) IFR

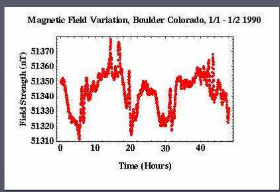
Secular Variation

- Observatories around the world provide data to the BGS in Edinburgh from which they make a prediction model called BGGM
- British Global Geomagnetic Model



Diurnal Variation

- The earth is constantly bombarded by ionised material from the solar wind creating a ripple effect in the magnetic field.
- The earth is also rotating creating a sine wave effect in the magnetic field.
- By observing distant land stations in real time, the diurnal effects can be interpolated locally.
- This is known as Interpolated In-Field Referencing or IIFR. (not to be confused with IFR)



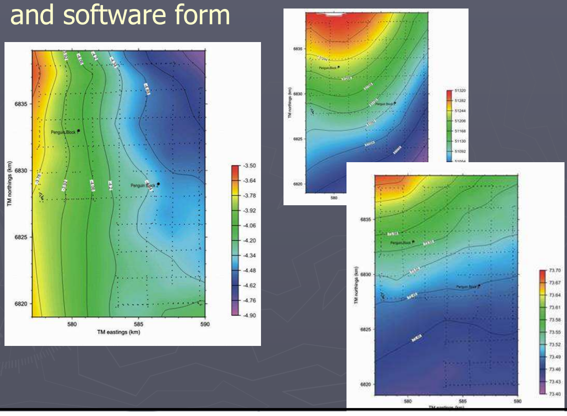
Crustal Variation

- Caused by the magnetic effect of deep basement rock.
- Cannot be corrected with Global models
- Can be a degree or more in declination
- Must be measured in the field

Measuring the Earth Vector On Land

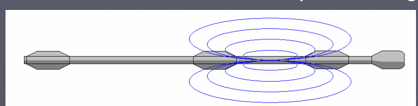
IFR by Air Land and Sea

Results in graphical and software form



Magnetic Interference

- The interference created by the collars in the BHA can influence the observed azimuth by several degrees.



- Short Collar solutions only use the X and Y mags to calculate the azimuth
- Multi Station Analysis uses the fact that as the BHA changes toolface and attitude, the background magnetic field is unchanged but interference components rotate with the BHA. We can therefore back out the interference components over several survey stations

Summary

- Reducing error is nearly always possible
- Sag is usually the biggest benefit in Vertical
- IFR is usually the biggest benefit in Horizontal
- Short Collar should only be used with caution
- MSA is only reliable in an accurate mag field
- SC and MSA do not work well when Bz small
- For high accuracy work nothing beats gyros

Conclusion

If we don’t get the message out that wellbore positioning is worth spending money on, we will continue to waste reserves and occasionally risk lives.