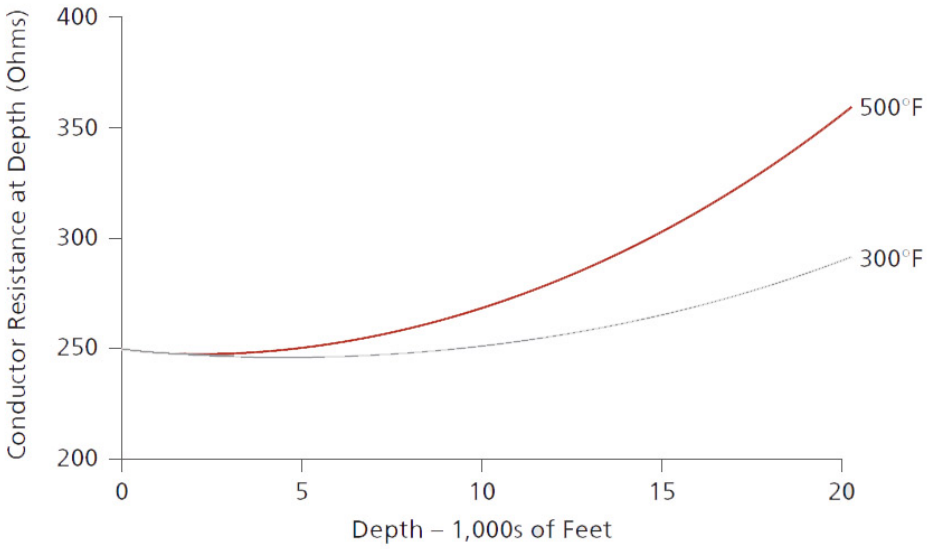
Increase in Cable Resistance with Wellbore Depth

The temperature of the earth increases with depth. The rate of temperature increase can vary from 10 to 25 degrees Fahrenheit for each one thousand feet increase in depth. With the increase in temperature there is an increase in the resistance of copper conductors. The resistance of copper, in fact, will double at a temperature of 370°F. This higher conductor resistance will directly increase the attenuation of signals and increase the power requirements to operate downhole tools.

The plot shown below shows the overall increase in conductor resistance as a tool is lowered in the hole. For this example the total conductor resistance of a 25,000 foot cable is shown as the tool is lowered in a 20,000 foot well with bottom hole temperatures of 500°F and 300°F.

Conductor Resistance Versus Depth



Graph is based on the following formula

$$R = r\left[(L-d)\left(\frac{(234.5+Ts)}{(234.5+68)}\right)+d\left[\frac{\left[\left[234.5+\left[\frac{\left(Ts+\frac{d}{Hd}(Tb-Ts)\right)}{2}\right]\right]\right]}{(234.5+68)}\right]\right]$$

For the above graph the following values were used

R = Total conductor resistance – Ohms.
r = Resistance per 1000 feet at 68°F, (20°C) – Ohms/Mft, (9.80hms/Mft).
L = Total length of cable – Mft., (25Mft).
d = Depth of cable in bore hole – Mft.
Hd = Hole depth to bottom – Mft., (20Mft).
Ts = Temperature at the surface – degrees F, (75°F).
Tb = Bottom hole temperature – degrees F, (300°F & 500°F).

To convert from meters to feet: 1 foot = 0.3048 meters
To convert from Celsius to Fahrenheit: T°F = (T°C x 1.8) + 32