The static shift problem in MT

Knútur Árnason
ISOR
Iceland GeoSurvey
MT-sounding

Electric dipoles

Magnetic coils

\[ \rho_{xy} = \frac{1}{\omega \mu} \left| \frac{E_x}{H_y} \right|^2 ; \rho_{yx} = \frac{1}{\omega \mu} \left| \frac{E_y}{H_x} \right|^2 \]
The reason for the MT static shift

MT (as well as DC methods) suffers a static shift problem because it relays on measuring electric filed (voltage over short distance) in the surface

The term “static or telluric shift” is used because apparent resistivity is distorted by a multiplicative constant, S, and hence by a shift when presented on a log scale

Two main reasons

1. Electric field distortion

2. Current distortion (current channelling/repelling)
Electric field distortion

\[ E_1 = \rho_1 \cdot j \]
\[ E_2 = \rho_2 \cdot j \]
\[ \rho_2 < \rho_1 \]

\[ \rho_{a1} = \frac{1}{\omega \mu} \left| \frac{E_1}{H} \right|^2 \]
\[ \rho_{a2} = \frac{1}{\omega \mu} \left| \frac{E_2}{H} \right|^2 \]
\[ = S \cdot \rho_{a1}; S < 1 \]
Current distortion

\[ \rho_{aA} = \frac{1}{\omega \mu} \left| \frac{E_A}{H} \right|^2; \rho_{aB} = \frac{1}{\omega \mu} \left| \frac{E_B}{H} \right|^2 = S \ast \rho_{aA}; S < 1 \]
In the examples shown, $\rho_2 < \rho_1$ resulting in $S < 1$.

In the case when $\rho_2 > \rho_1$ we get $S > 1$.

When apparent resistivity is presented on log scale we get a shift by $\log(S)$.
Central loop TEM, the remedy

At early times, after the current is turned off, the response depends on shallow resistivity but the induced currents propagate to greater depth with time and the apparent resistivity becomes independent of shallow resistivity variations.
Since the TEM is not affected by near surface inhomogeneties at late times joint, a interpretation of TEM and MT can be used to correct for the shift. The TEM and MT data are fitted by one model and the shift multiplier, S, is taken as one of the model parameters.
A histogram of static shift multipliers in the Krafla filed, N Iceland
A map showing spatial distribution of static shift multipliers, S, for MT soundings in the Krafla field, N Iceland
A map showing spatial distribution of static shift parameters, S, for MT soundings in the Asal Rift in Djibouti, East Africa.
Other attempts to shift correction

Some people have tried to use other method to correct For static shifts. These are normally based on spatial Filtering or some assumptions about the statistical Distribution of the shift multipliers. One such is assuming That the product of all the multipliers for many soundings Covering a big area is close to one.

Experience from Krafla and the Asal Rift is:

<table>
<thead>
<tr>
<th>Field</th>
<th>Nr. of soundings</th>
<th>Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Krafla</td>
<td>130</td>
<td>$1.3 \cdot 10^{-10}$</td>
</tr>
<tr>
<td>Asal Rift</td>
<td>77</td>
<td>$1.6 \cdot 10^{-16}$</td>
</tr>
</tbody>
</table>
Conclusions

1. Static shifts can be a severe problem in MT soundings
2. If not properly corrected, interpretation can lead to very misleading interpretation. Shifts as low as $S = 0.1$ have been observed which would lead to 10 times too low resistivity values and 3 times too shallow depths to resistivity boundaries.
3. The MT data cannot be used to correct themselves for static shifts.
4. TEM data can be used to effectively correct for static shifts in MT data by joint inversion.
5. Interpretation of MT data without correction by TEM cannot be trusted except, maybe, in areas where it is known that little or no near surface inhomogeneities are present (thick homogeneous sediments)