COMPLEMENTARY INVESTIGATIONS ON THE CALIBRATION ERROR OF THE TELLUROMETER (*)

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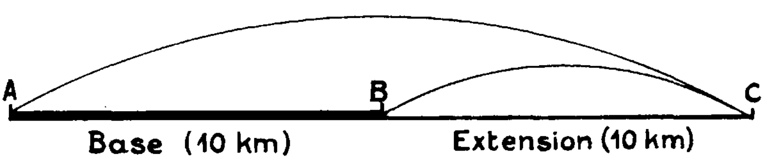
During spring 1961 the Institut Géographique National resumed investigations on the calibration error of the tellurometer for ranges greater than 12 km.

For shorter ranges the investigations are simple : it is only necessary to measure baselines or sections of baselines. It was found that the error for a given instrument is constant (to about 1 or 2 cm) between 0 and 12 km.

Baselines longer than 12 km do not exist (at least, not in France) and an indirect method must be used. The first experimental operations in 1959 gave the following result: beyond 10 km the tellurometer error seemed to decrease, according to the distance, to 6.3 mm per km on an average. This result needed verification.

In 1961 the following method was used (see figure).



Station C was accurately positioned on the extension of the AB baseline at about 10 km from B. The AC and BC sections were most carefully measured with the tellurometer. The indirect measurement AC - BC gave an AB baseline value that provided, by comparison with the true value, the error ε. If, beyond 10 km, the tellurometer error varies according to the distance, the error formula will include one constant term A (error value between 0 and 10 km) and one variable term f (dependent on d and equal to zero between 0 and 10 km):

(*) Supplement to the article *Results of trials on the conditions under which the tellurometer is used* published in the Supplement to the International Hydrographic Review, volume 2, October 1961.

$$e = A + f(d), \text{ with } f(d) = 0 \text{ if } d \leqslant 10)$$

At 10 km the error is $e_{10} = A$, because $f(10) = 0$.
At 20 km it is $e_{20} = A + f(20)$.

In the above experiment, the AC—BC difference error is the difference between e_{20} and e_{10} :

$$\begin{aligned} \varepsilon &= e_{20} - e_{10} \\ &= A + f(20) - A = f(20) \end{aligned}$$

As it can be foreseen, the constant term (which may even be unknown) is eliminated and the $f(20)$ value is obtained.

The only difficulty in the method is finding a suitable site; both the AC and BC sections must be homogeneous, which means that the ground is relatively flat and uniform along the whole AC section, with low elevations in the desired places, i.e. at A, B and C, with the rise at B low enough not to obstruct the line of sight between A and C; parasite reflections must be slight over both sections. In addition, it is necessary to operate under the most favourable conditions: moderate wind, equal insolation, equal vapour pressure at the two ends of the line to within 0.3 mm Hg.

The experimental measurements were carried out twice over the same line, under very different temperature and vapour pressure conditions in order to detect the possible effect of these factors. The two ε values obtained were —5 and +19 mm.

As these values are within the instrumental accuracy limits (from 1 to 2 cm), they can be considered as zero. Therefore $f(20) = 0$.

Thus, it can be concluded that the tellurometer *error* is constant (to 1 or 2 cm) *between 0 and 20 km*.

This simple result does not agree with the conclusion reached in 1959. Because the accuracy of the two methods is not at all the same, it is logical to adopt the 1961 result and to eliminate the 1959 conclusion. It seems that the 1959 inaccuracy is due to three factors :

— Instead of using a line including one section AB which is a baseline and of which the length is therefore previously known, any AC line was used, and the three distances (the AC line and the AB and BC sections) were measured with the tellurometer. Under these conditions, the tellurometer error was included in the direct AB determination, and *the constant term A was not removed*. Therefore it was necessary to know this term precisely (i.e. it should have been accurately measured on *a number of lines*), and its value should have remained absolutely constant;

— The lines used were not homogeneous (a 300-metre elevation in one section and a plain in the other);

— The season was not favourable (light or no wind, vapour pressure different at the two ends).

Beyond 20 km, the error was not investigated. This would hardly be possible in France, because it is difficult to find homogeneous lines. In addition, there are few reasons for thinking that the calibration error is dependent on the range beyond 20 km.

It is concluded that the tellurometer error can be considered as constant in relation to distance. On the other hand, it varies from one instrument to another or, more exactly, from one remote instrument to another (the error remains the same when one master instrument is substituted for another). Its value is generally between 0 and 8 cm and it is necessary to check it from time to time, in order to prevent possible drift.

To obtain the value of this error, the best way is to operate on a short line (0.5 km, for instance). Indeed, on such a line the temperature is usually homogeneous and the effect of a possible index of refraction error is very slight. The use of 5-metre high towers is absolutely necessary in order to avoid the ground error which can be considerable (from 10 to 20 cm) at this range. Of course, the line must be taped and observations should last several half days for each calibration.