ALLUVIAL TERRACE GEOMETRY IN FRENCH JURA ESTIMATED FROM DC ELECTRIC AND TDEM MEASUREMENTS

Jean Christophe Gourry[1], Roger Guérin[2], Yves Albouy[3] and Thierry Winter[1]

1. BRGM, Research division, avenue Claude Guillemin BP 6009 45 060 Orleans, France
2. P & M Curie Univ., Applied Geophysics Lab., 4 place Jussieu, 75252 Paris, France
3. ORSTOM, 32 avenue Henri Varagnat, 93143 Bondy cedex, France

Introduction

The aim of this work is the determination of the neotectonic activity of the Jura mountains. Alluvial terraces are a good index of mountain uplift. Our hypothesis is to use the terrace base as a reference. With the age and altitude variations, we could also calculate the uplift velocity variations during the last hundred thousand years.

Then a test of DC electric and TDEM measurements was carried out in the Seille valley (french Jura) for mapping alluvial terraces.

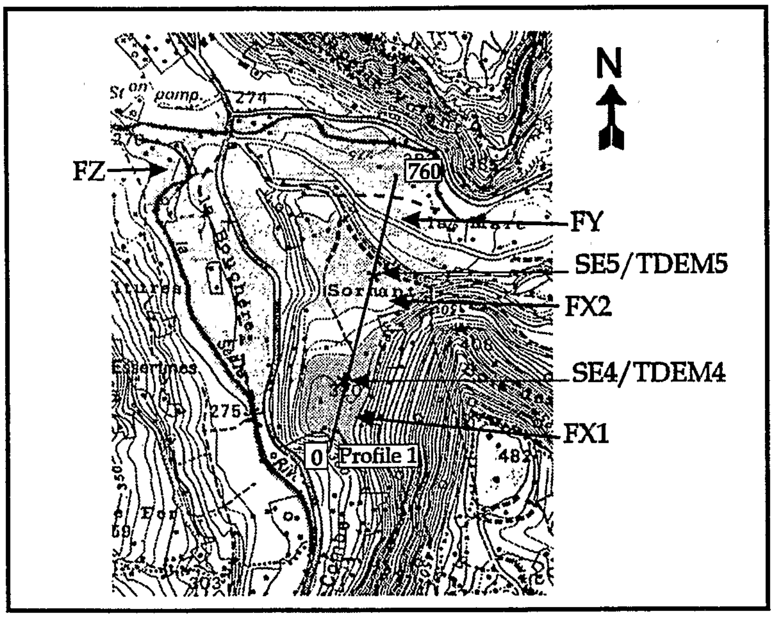

Fig 1 – Geologic map of geophysical survey.

Geological context

The work area is situated on the East Jura front in the Seille Valley. Seille river digged a encased valley in a 100 m deep canyon upstream. Downstream the valley topography is faint. Autochton terrains are constituted with lower lias (limestone and marl) and upper trias series (upper Keuper anhydrites). From the ancientest to the most actual, 4 terrace ages are called Fx1, Fx2, Fy et Fz. They are constitued with limestone pebbles in a sand-clay matrix. Graded bedding is observed on some outcrops.
Two study areas were selected : the first one upstream in Nevy/Seille village (area 1), the second one downstream in Bletterans region (area 2). Area 1 is situated at the confluence of two arms of the river (figure 1). Area 2 seems to be a large glacial valley.

Geophysical survey on alluvial terraces

A terrace can be characterized by its resistivity which contrasts with country rock. On area 1, a 760 m DC electric profile was achieved towards the valley on terraces of different ages to estimate their thickness' (figure 1). 5 m spacing electrodes pole-pole array was chosen until n = 16. Electrical soundings (AB/2 = 150 or 300 m) were also carried out on these terraces to estimate their resistivities and thickness'.

Field measurements were carried out with the ProtemEM47 system (Geonics Ltd.) using three overlapping base frequencies (« u » 237.5 Hz, « v » 62.5 Hz and « H » 25 Hz). We laid out central measurements using 50x50 m transmitter loop (TDEM4 and TDEM5 soundings), and offset measurements using 25x25 m loop and 32.5 m offsets (TDEM7 sounding). Each frequency-based acquisition typically result into 20 normalized voltages logarithmically spaced in time.
The field data acquired were interpreted with layered models using the TemixGL (Interpex Ltd.) interpretation software. Equivalencies calculated for all models help in defining the « average » model.

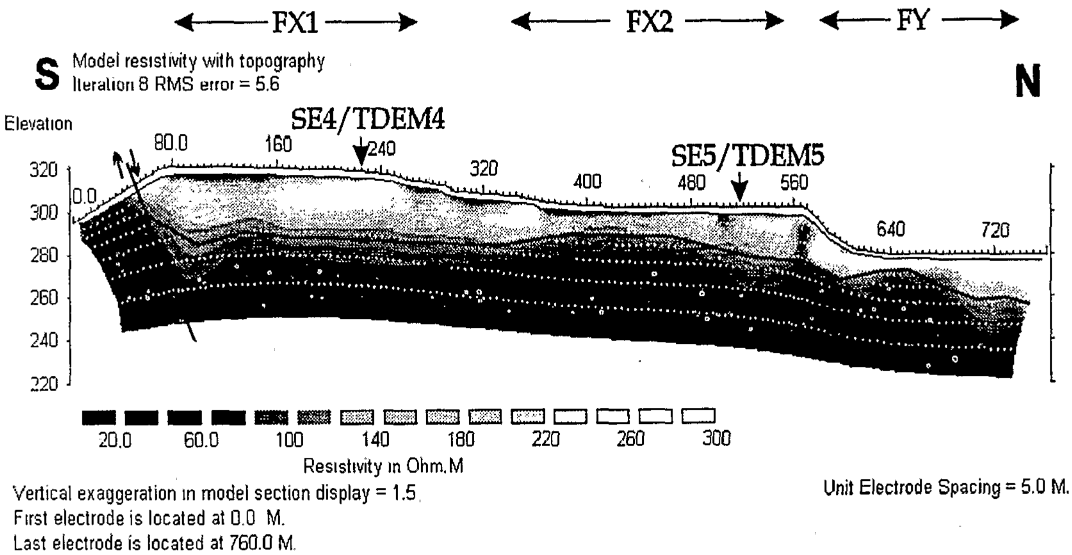

Fig 2 – Result of the inversion of pole-pole electrical data. Positions of electrical soundings (SE4 and SE5) and transient electromagnetic soundings (TDEM4 and TDEM5).

Inverse and direct modelings were computed taking into account the topography.

On figure 2, we can see the geometries of three terraces. A forth is also visible between 320 and 470 m. The deepening of Fy terrace at the end of the profile can be explained as paleo-channels of the Seille river. A fault is observed in the south of the profile.

Comparison of DC electric profile with electrical soundings (figure 2 and 3) gives excellent correlation.

Firstly, electrical soundings were interpreted separately from TDEM soundings. Secondly, we mixed both results to eliminate equivalencies.

On SE4/TDEM4 and SE5/TDEM5 points which are resistive terraces, TDEM and electrical soundings give the same estimation of the terrace thickness (20 m and 25 m respectively). But TDEM resolution is lower than electrical sounding : layers shallower than 5 m are not detected and graded bedding (SE5/TDEM5) is not resolved with TDEM. But field measurements are faster and cheaper with TDEM than with vertical electrical sounding.

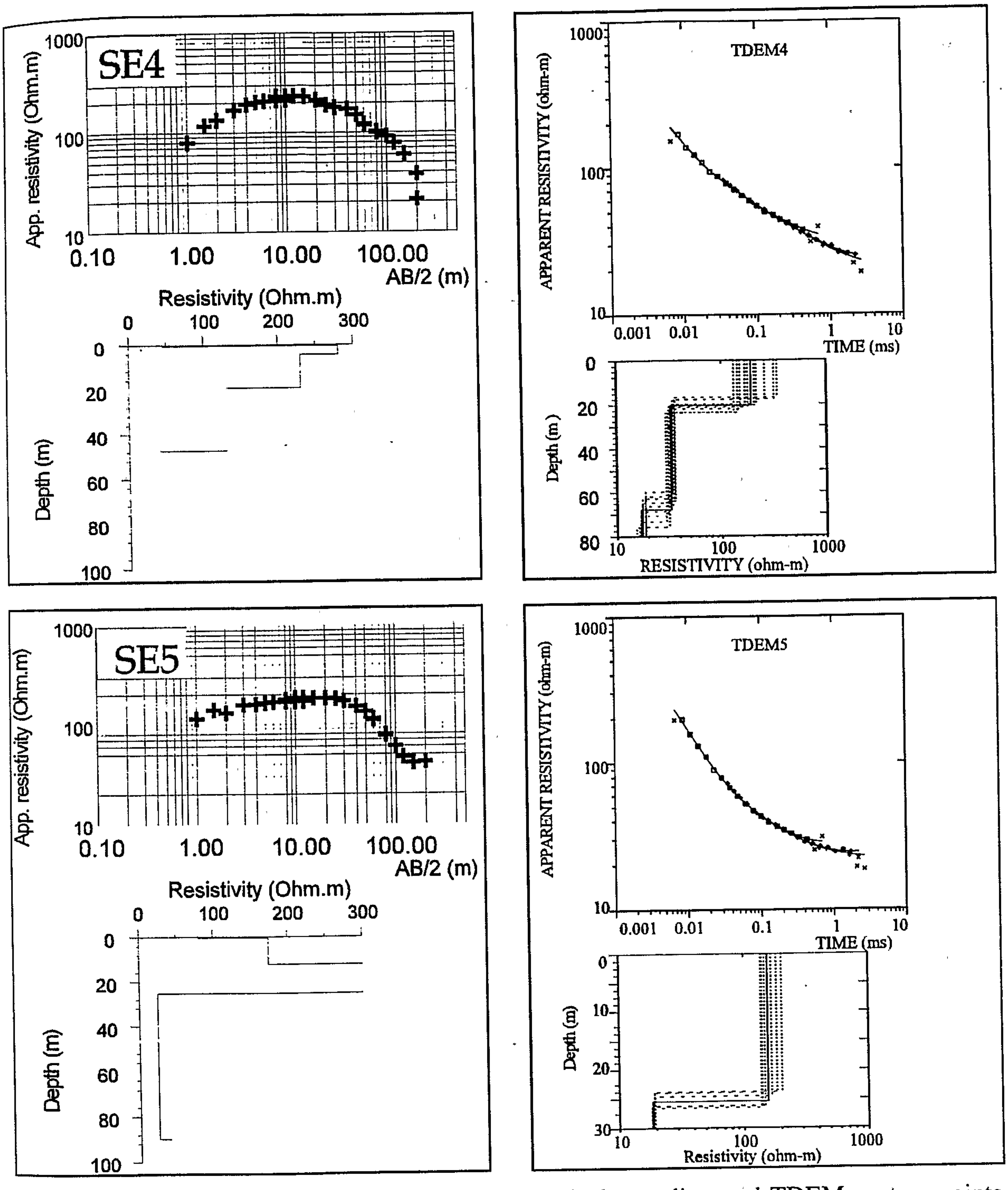

Fig 3 – Comparison of data and results with electrical sounding and TDEM on two points : SE4/TDEM4 and SE5/TDEM5. Dotted lines on TDEM results are equivalent models.

Comparison of AMT with TDEM results

TDEM were used to estimate the thickness of a glacial lake which was filled with alluvial sediments. The orientation of the ancient valley is East-West. A central-loop configuration was performed using 100x100 m loop for three soundings. This method was compared with AudioMagnetoTellurics (AMT) on the same points. Both methods have the same depth of penetration.

In this context, we found that TDEM measurements quality is good, while a large noise occurs AMT data. Finally, we can fit the same model on both data. The glacial valley was filled with sediments (70 to 180 Ω.m) over a 90 m thick resistive layer (110 to 165 Ω.m liasic limestone) and a conductive layer (9 Ω.m triasic evaporites). The thickness of alluvial sediments increases from 35 m in the south of the valley to 52 m in the north. Water table was also detected.

Conclusion

These geophysical results are the first step of a research project for estimating the past and present tectonic activity of the French Jura. Next step will be the determination of the ages of terrace deposits.

We saw that electric and electromagnetic methods are convenient for the estimation of alluvial terrace thickness. DC electric profiles are calibrated with electrical soundings because TDEM resolution is too low for the problem.

In contrast TDEM is the most efficient technique for the evaluation of deeper layer (more than 20 m).

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