

SNMR soundings in the Baucau region of Timor-Leste for groundwater management

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SUMMARY

We examine some surface nuclear magnetic resonance soundings, which are tied into an airborne electromagnetic survey, for groundwater management and water exploration. In this paper, we discuss the locations of SNMR sounding sites, based on the AEM, and show some of the groundwater models obtained to inform a drilling program for obtaining more groundwater for the town of Baucau, Timor-Leste.

Key words: SNMR, TEM, airborne electromagnetics, Timor-Leste, groundwater.

INTRODUCTION

Baucau is the second largest city in Timor-Leste. Although the current population is only 16000, it is expected that this will increase fourfold by 2030. This will cause increased pressure on the water resources for the city and the surrounding area. Situated on the northern side of the Baucau Formation, a weathered limestone shelf that was uplifted a few million years ago, the region gets about 1500 mm rainfall per year with acts as direct recharge for the groundwater resources upon which the citizens depend. Groundwater is currently obtained from natural springs in the town centre and pumped back up to the top of the shelf. In neighbouring villages, groundwater is obtained from local springs.

Besik (Bee, Saneamentu no Ijiene iha Komunitade, BESIK, 2015) is an Australian Government-funded program responsible for assisting and advising the Government of Timor-Leste to expand and improve water distribution and delivery to the cities and districts of Timor-Leste. Following on from previous work in the region of Baucau by Besik and Geoscience Australia, an airborne electromagnetic (AEM) survey was flown over the Baucau Formation in an attempt to determine the thickness of the limestone layer and to assess the distribution of potential groundwater reserves. From an examination of the AEM data, we selected 10 locations of interest that warranted further investigation. At the request of Besik, the CSIRO became involved in a campaign of surface nuclear magnetic resonance (SNMR) measurements as a precursor to drilling.

In this presentation, we show the results of the SNMR campaign in the Baucau region of Timor-Leste. Specifically, we show the locations of possible palaeovalleys and preferential drainage paths, and show where drilling should occur to place future

production bores for increased water security (Davis and Ley-Cooper, 2015).

METHOD AND RESULTS

Figure 6 shows the extent of the AEM survey undertaken on the Baucau Limestone Formation prior to the SNMR field work. The total coverage was 170 km² with 49 lines separated by 200 m. Reprocessing and inversion was completed and 2 regions of interest were selected for further investigation. Figure 1 shows the elevation of the bottom of the first layer from a blocky-model conductivity-depth inversion conducted for the AEM survey. Since the first layer in this region was extremely resistive, it is inferred that the layer is part of the Baucau limestone formation. The contact layer shown in this figure is interpreted to be the underlying Viqueque Formation (marl and claystone), and hence, an aquitard to the water stored in the Baucau Limestone (eg, United Nations, 2003; Thompson, 2011)

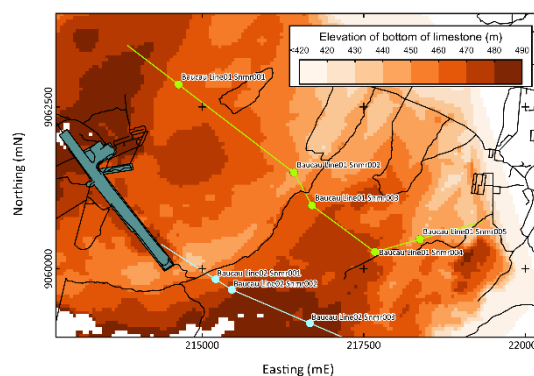


Figure 1: Elevation of the bottom of the limestone in the NW section of the AEM survey area.

For this region of interest, 2 SNMR survey lines were chosen so that the locations of the soundings were as close as possible to the valley formation seen in Figure 1 (lightly shaded area, trending northeast). As a result, 8 SNMR locations were chosen to help typify the classes of aquifers found near Baucau. At each location, a ground-based TEM sounding was conducted using 40 m square loops. This was in order to provide some ground truth to the AEM conductivity results. Figure 2 shows the inverted conductivity-depth for location 3 in line 1 of the Baucau survey area. It is very clear that the ground is extremely resistive.

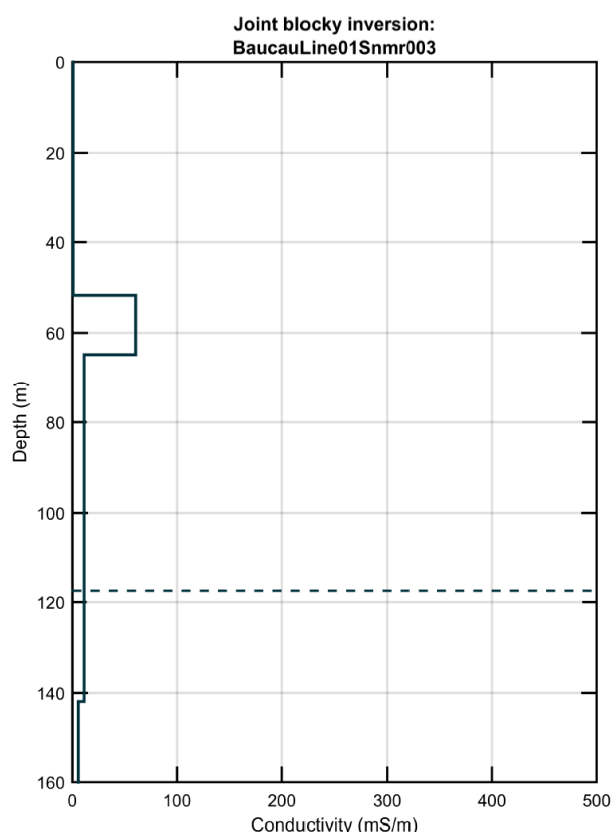


Figure 2: Inverted conductivity-depth model from location 3 on SNMR line 1 in the Baucau survey area.

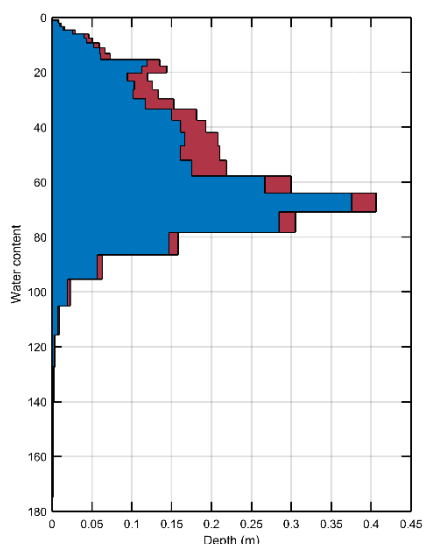


Figure 3: Inverted water content for SNMR location 3 on line 1 near Baucau.

Figure 3 shows the inverted water content model for the sounding location chosen. We can see clear evidence of the groundwater table beginning at about 10 m below surface, followed by a steady increase of groundwater content with depth to about 70 m. Comparison with the TEM results shows that there is most likely an aquitard below 70 m, and this is reflected in the sudden drop in groundwater after 70 m depth.

The high water content at 70 m is most probably due to the heavy weathering of the Baucau Limestone formation in this area (Figure 4).



Figure 4: An example of the heavily weathered limestone in a surface expression of the Baucau Formation, Timor-Leste.

By inverting the TEM and SNMR soundings for every site in the region, we tie the SNMR groundwater estimations to the AEM survey results. Figure 5 shows an AEM section with SNMR groundwater inversions superimposed on the conductivity.

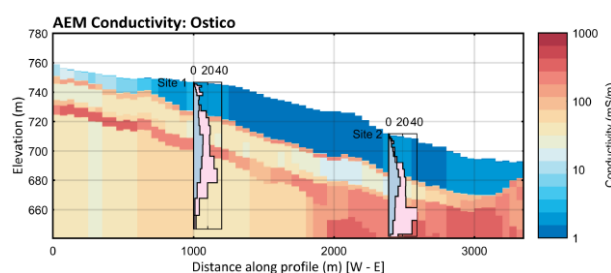


Figure 5: SNMR soundings superimposed on an AEM conductivity-depth section for a survey line near Ostico in the south-western section of the Baucau AEM survey.

Examination of the figure clearly shows the upper Baucau Limestone Formation, declining toward the east of the figure. There appears to be another layer, which may be the saturated zone of the Baucau Formation, which overlies an aquitard that is inferred to be part of the Viqueque Formation. The saturated layer, which has very low conductivity, may be a future groundwater resource.

CONCLUSIONS

We have shown some brief examples of a combined SNMR and TEM groundwater study that uses an existing AEM data set for background information. The results of the SNMR survey will be used to inform a drilling campaign to be scheduled early in 2015.

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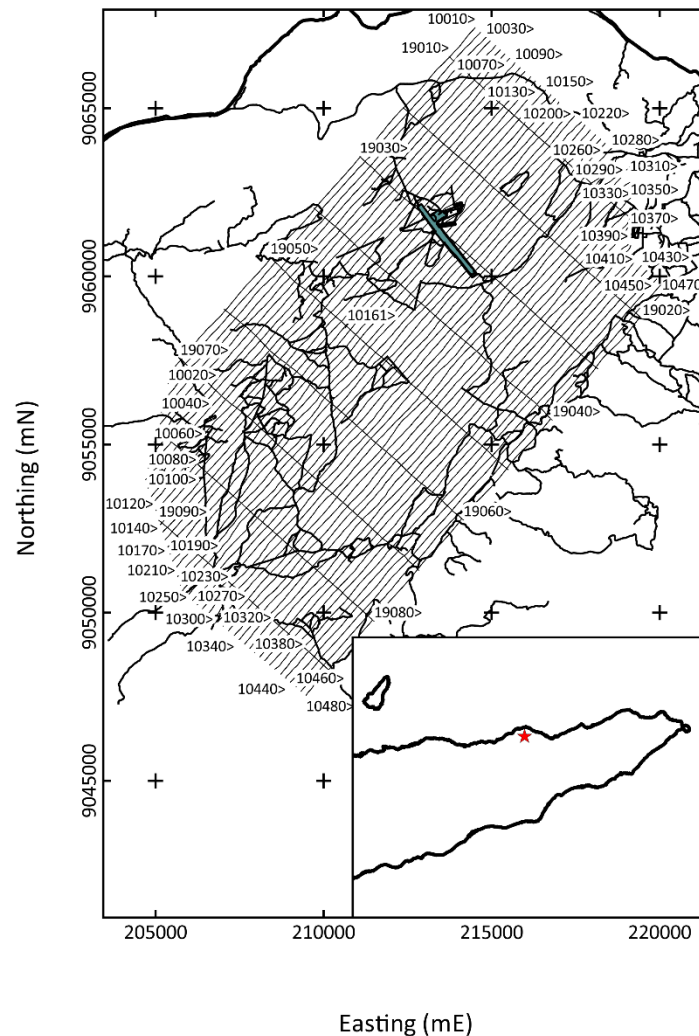


Figure 6: Location of the AEM survey for the Baucau resion of Timor-Leste.