# How to Make a Map from an Outcrop

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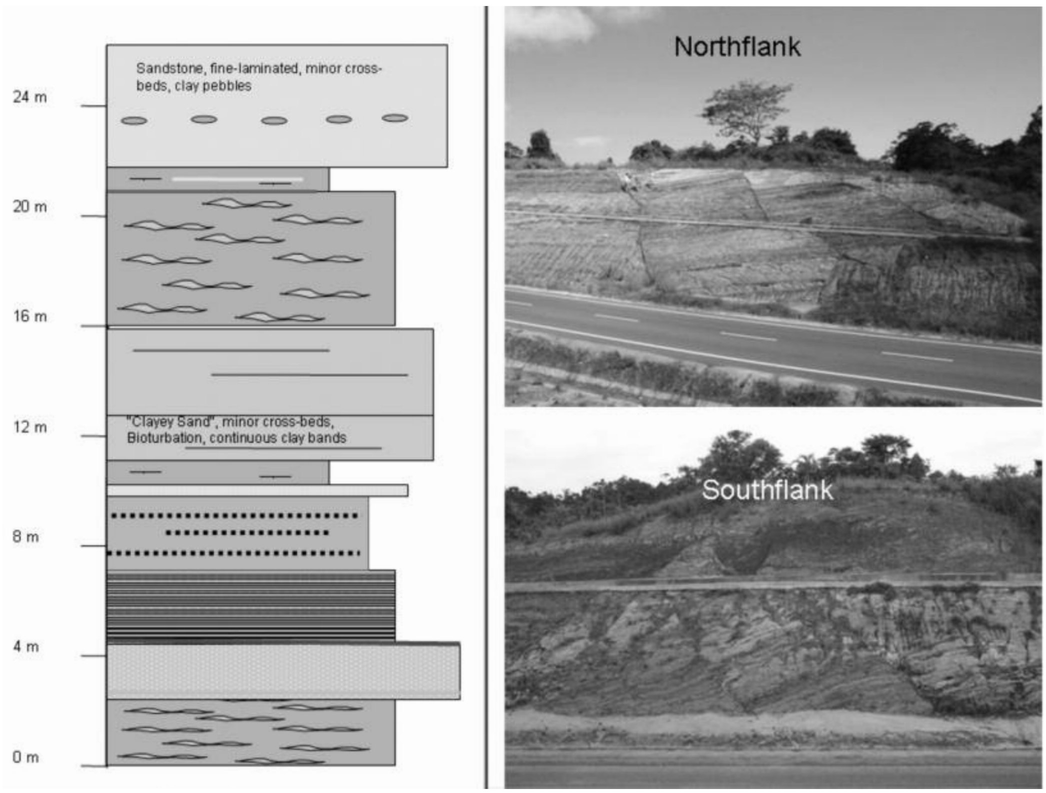


*Fig. 1: Both flanks of the road display outcrops. Please note that the oldest part of the stratigraphic sequence is found on the crest of the Southflank, and the youngest on the crest of the Northflank. Sedimentary deposits are of intertidal origin.*

This paper shows the process of generating a reasonable map from a complex clastic outcrop near Miri, Sarawak, Malaysia. Steps are: measure the outcrop, establish fault type and throw, fault strike, fault dip; proceed with data synthesis; make a fault model, a data grid; and finally, a map.

## I. Introduction

With an overwhelming, and sometimes naïve emphasis on technology and reliance on computer automation ("Nintendo geology," "Black Box monkey geology"), the basic but absolutely essential discipline of extracting geological information from outcrops is in danger of being sidelined. Students of petroleum geology often are not sufficiently trained in mapping and map generation – although these skills are vital in the context of prospect creation. From the standpoint of petroleum business, in which geoscientists are mainly confined to the office environment with geological interpretation being conducted on workstations, the neglect of field geology is somewhat understandable: outcrop data are difficult to translate into numbers, and to incorporate such numbers on the long road from geology to money is sometimes an art by itself. This said, however, it is argued that outcrops are more than venues for social events and/or brain stimulators, and some of us are still enjoying tremendously attending occasional field trips. The chosen example (Fig. 1) is an extremely tricky one. Located some 40 km SW of Miri, Sarawak, this Coastal Road outcrop offers excellent insight into fault-seal and clay-gouging dynamics.

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## II. From outcrop to map

Step 1: Measuring an outcrop: The best thing to start with is camera, notebook, and a GPS. This way, important landmarks, horizon-fault intersection points, etc. can be captured. The GPS data can be made easily decimal, and imported into an Excel spreadsheet. It was useful to add a scale to the outcrop – in this case every meter of the outcrop was marked along drains that intersect the outcrop in mid-section.

Step 2: Strike and dip: Here our main tools are compass, hammer/knife, measuring tape, and notebook.

Step 3: Data synthesis: All the data are plotted onto one sheet that shows all the data – GPS, horizons, horizon thickness, faults, fault throw, relief, and landmarks. This is shown in Fig. 2 on next page.

Step 4: Making a fault model and a data grid: Most outcrops are 2-dimensional, the cited example is somewhat 3-dimensional though complex. Grids can be generated by: (1) correlating

**Technical Note** *continued on page 57*

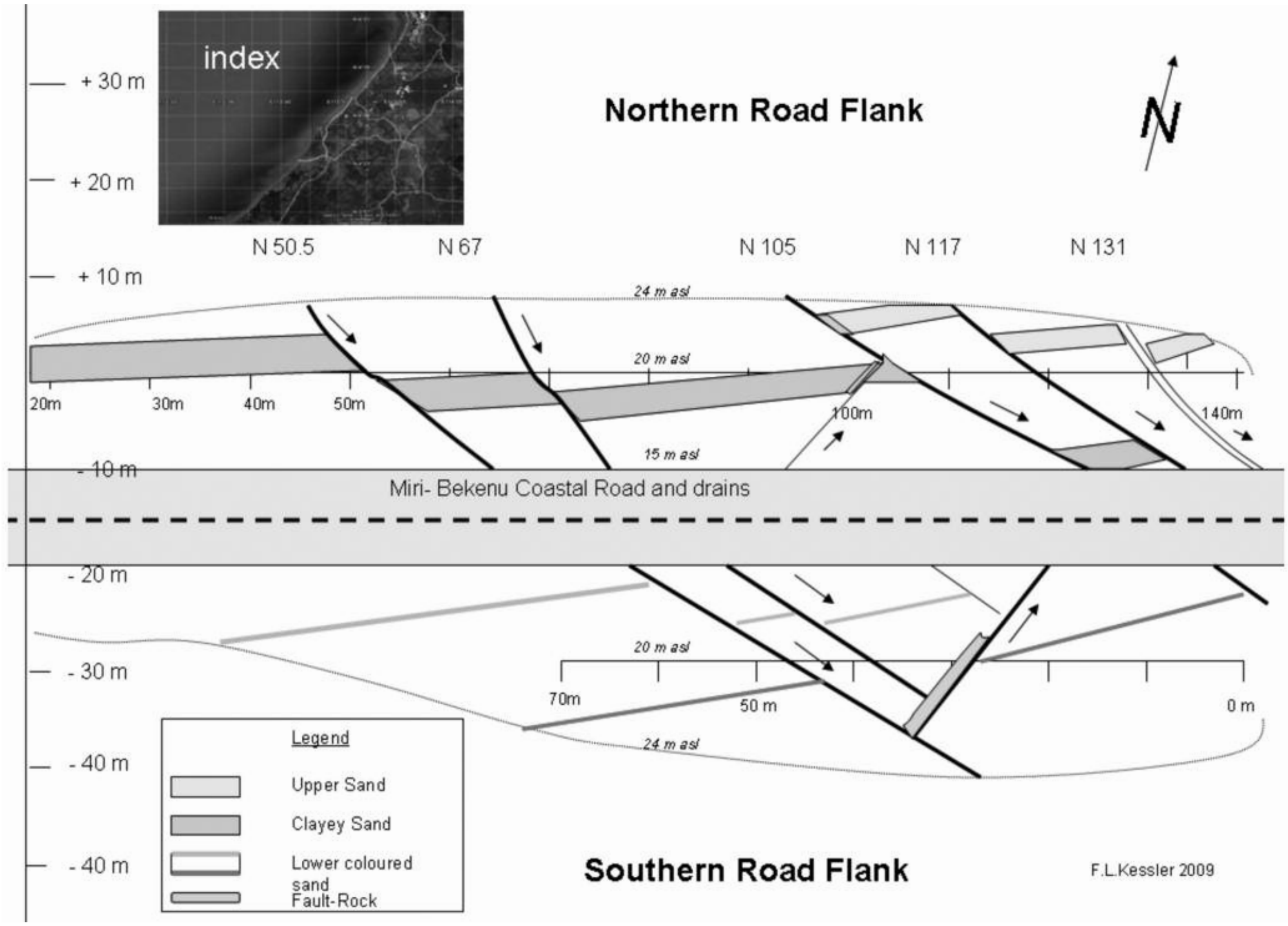


*Fig. 2: Map of the outcrop Note that the rocks are dipping 80 deg NW which gives the outcrop a "map-view" flavour.*

horizons and faults between several outcrops, and using interpolation techniques; (2) by outcrops into a well; or (3) simply by extrapolating strike and dip data (as is done here) as long as this can be justified in the context of the regional setting and sound structural model.

Extrapolating fault data is always tricky, but there is a statistical relationship between fault throw and length of a given fault [Walsh and Watterson, 1988]. A good rule of thumb is that faults are mostly 10-times longer than their throws. Using the existing strike and dip data, it is possible to create a data grid. Such a grid should be regular – in this example grid nodes with 10 m distance are chosen. Furthermore, in order to define faults, grid points first need to be defined. In this example, points for the up- and down-thrown sides of the faults were picked every 10 m on the y axis.

Step 5: Data export: Data can be exported as X, Y, Z files to any commercial mapping package.

Step 6: Gridding and contouring are performed. The final map is shown in Fig. 3.

### III. Map Applications

There can be a variety of applications. In this example, the goal was to provide data for a clay gouging and fault rock simulation, to compare model simulation results with measured data, and to predict the clay gouging and fault rock prediction on larger faults seen on seismic [Kessler et al., in preparation]. ■

**Technical Note** *continued on page 59* continued from page 57



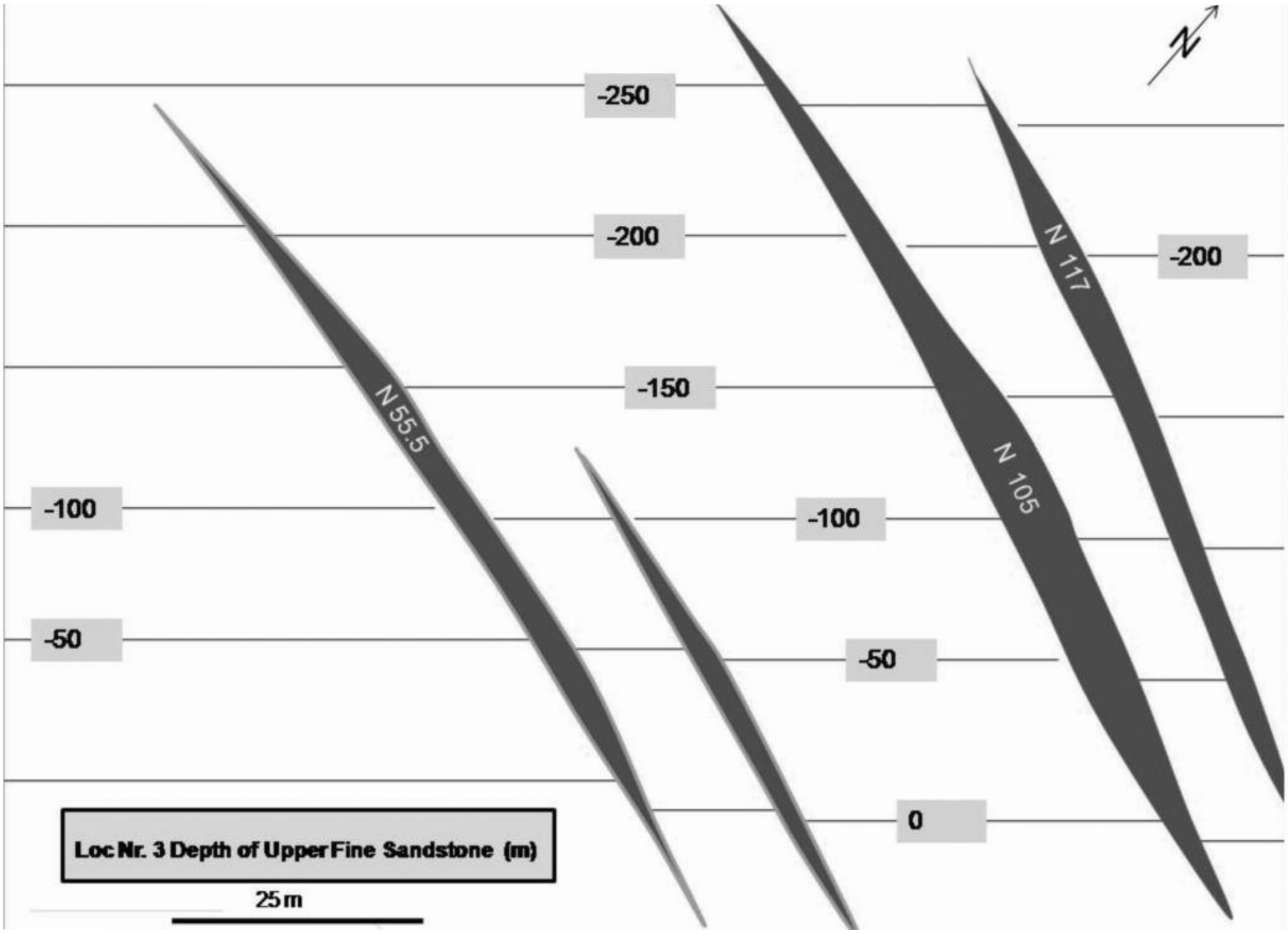


*Fig.3: A simple depth map for the area NW of the outcrop, derived from the outcrop data.*

**IV. Acknowledgements**

The authors wish to thank Titus Murray (FaultSeal Pty Ltd) for fruitful discussions.

**V. References**

Kessler, F. L., Murray, T. and Jong, J (in prep). Faulting and Clay Gouging in Neogene Clastics of the Lambir Fm., Sarawak, Poster Abstract, Petronas Geological Conference and Exhibition, Kuala Lumpur, 29-30th March 2010.

Walsh, J. and Watterson, J. (1988): Analysis of the relationship between displacements and dimensions of faults, J. Struct. Geol., 10, 239-247, 1988