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TrackDip: A multi-scale processing of dipmeter data – Method, tests, and field example for 3-D description of gravity-driven deformations in the Eocene foreland basin of Ainsa, Spain

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ABSTRACT

This paper presents TrackDip, a new method for dipmeter data processing. This method selects, localizes and measures significant tilts from the comparison at various scales of the changes of orientation of sedimentary beddings. We tested this method on simple cases (unconformity, gradual tilt, successive tilts, without and with additional random noise) and on a field example, along three sections in the Eocene Sobrarbe delta, Ainsa foreland basin, northern Spain. For synthetic data sets, the method clearly identifies and measures the introduced tilts.

On the field, sedimentary and tectonic structures, especially three main syn-sedimentary sliding surfaces (S1–S3), were successfully identified from processed dipmeter data. The tilt axis are mainly trending N–S in sandstones, associated to Westward transport of sediments. The sliding surfaces S1 and S3 correspond to E–W-trending tilt axis, tentatively correlated either to the flexural subsidence of the basin, or to anticline growth during sedimentation South of the studied area. Combination of these sedimentary and tectonic directions results in a NE–SW striking submarine slope, which locally controls the gravity-driven deformations, especially on the S2 sliding surface. Finally, NNW–SSE-trending tilts above the uppermost S3 sliding surface are interpreted as the result of infilling on the side of the scar produced by sliding.

1. Introduction

Among downhole logging tools, dipmeters represent a class of tools designed to measure the orientation, i.e. both dip angles and azimuth (dip direction) of bedding planes intersected by a borehole. While boreholes are one-dimensional, dipmeter data allow to describe 3-D geometry of sedimentary units, and bring crucial information on all processes involving changes of orientation in sediment bedding, such as deposition in flows (e.g. Luthi and Banavar, 1988; Höcker et al., 1990; Donselaar and Schmidt, 2005), deformations during and after sedimentation (e.g. Hesthammer and Fossen, 1998), differential subsidence. It is noteworthy that these changes of orientation occur at various space and time scales, and that their effects are merged in a single record.

The word dipmeter refers only to dip measurements, and little has been done to fully use these three-dimensional measurements. The classical tadpole graphical display of dip and azimuth as a function of depth (Serra, 1989) underlines the dip variations, but azimuth variations are difficult to read. Interpretations often used mainly dip variations (Gilreath, 1987; Serra, 1989). Similarly, processing methods either used only dip measurements (Hurley, 1994), or are restricted to a given scale (point to point analysis: Berg, 1998; folded structures: Bengtson, 1981).

In this article, we present a new method, named TrackDip, to process bedding attitudes from outcrops in order to identify at various scales the successive changes of orientations in a sedimentary section. While designed to process dipmeter logging data, we tested this method on a field example, in the Eocene foreland basin of Ainsa (Spain). This test allows a direct comparison between interpretations from dipmeter analysis and outcrop exposures.

2. TrackDip processing of dipmeter data

The processing methodology described herein is a formalized version of the empirical process used by Basile (2000) on logging data. Annexes 1–4 present the successive stages of processing for the three data sets analysed in this paper.

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