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Structural Control of Turbidite Deposition in Active Asymmetrical Synclines, Annot Sandstone Depocentres, SE France

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The Annot Sandstone forms the upper unit of the foreland basin succession in the alpine fold and thrust belt of SE France. These sand-rich deep-water turbidites were deposited in a deltaic setting over period of 10 My (Bartonian - Rupelian) in actively deforming depocentres during SW directed compression (Joseph and Lomas, 2004). Today the Annot Sandstone is superbly exposed in asymmetrical synclinal remnants, where the interaction of turbidite sedimentation and folding can be studied in detail.

The poster focuses on two synclinal depocentres, those of Annot and the Grand Coyer. At Annot, the SW limb of an asymmetrical fault propagation syncline is preserved, while in Grand Coyer, the steeper, and more complex, NE limb of an active syncline can be studied. The characteristics of turbidite sedimentation across an active asymmetrical synclinal depocentre can be reconstructed from these two areas.

The Annot depocentre (gently dipping limb / gentle deformation)

Only the western limb of the synclinal, which controlled the turbidite sedimentation, is preserved in the Annot depocentre. On this western limb, the Annot Sandstone gently onlapped westward onto a slope of Globigerina Marls, typically having a value of 10°. Turbidite architecture was reconstructed in a 3D geometrical model, built from field data in the gOcad software. Derived thickness maps of five members within the Annot Sandstone (members B, C, D, E and F; Fig.1) document a westward progressive migration of the depocentre (Salles et al., submitted). From member B to member F (35-33 My; Du Fornel, 2004), the synclinal depocentre moved west about 3.5 km (Fig.1). Palaeocurrent directions is often parallel to local depocentres. The palaeocurrent directions are also strongly influenced by local structures (eg. Braux fault) (Fig.1).

Comparison of bedding dip data with idealized case studies of interaction of sedimentation and active folding demonstrates that, in general, depocentre migration and fold hinge migration should be analysed separately. In the Annot case, because bedding dips decrease up through the turbidite succession, the depocentre migration can be linked with a synclinal hinge migration (Salles et al.,

submitted). Using Trishear forward modelling software, precise near surface geometries constrain thrust geometry evolution at depth. Limb rotation and depocentre migration are reproduced between two fault propagation anticlines, with a coeval and/or alternating development. Two active detachment levels (Triassic evaporates and Cenomanian marls) are required to explain observed hinge migration (Salles et al., submitted).

In summary, on a gently dipping limb, fold growth mainly controls depocentre migration.

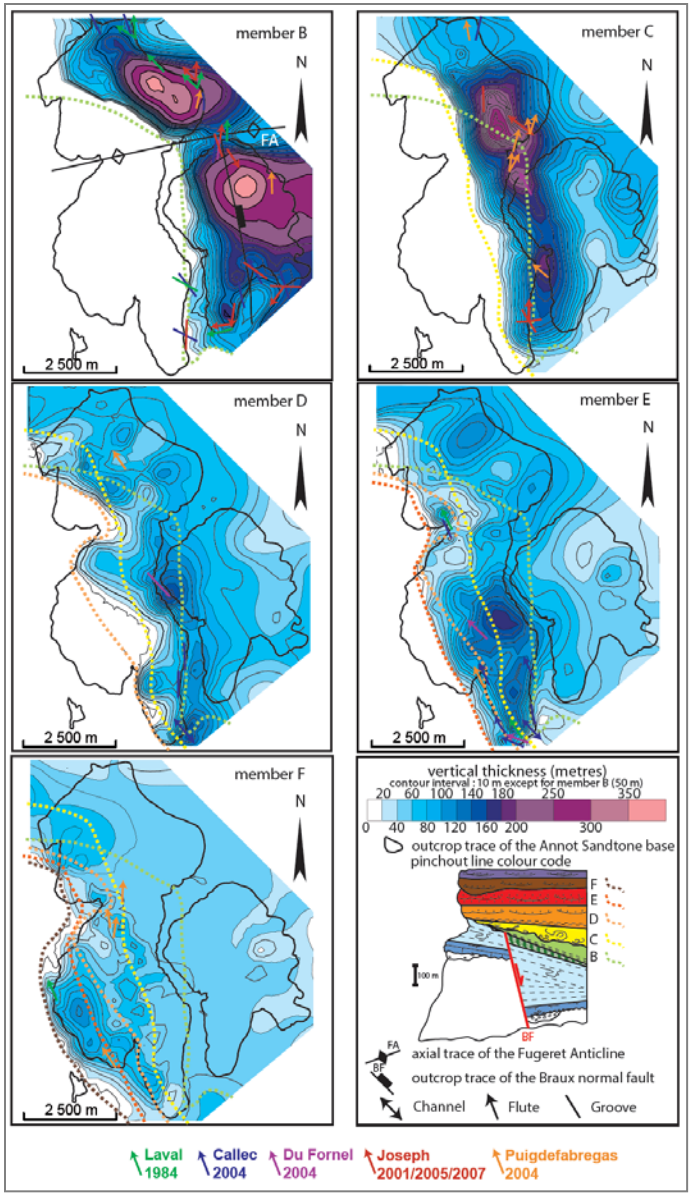

Figure 1 (see figure captions at the end of the text).

Eastern part of the Grand Coyer Massif (steep limb / strong deformation and erosional processes)

The study area in the Grand Coyer Massif corresponds to the easternmost outcrops, where the Annot Sandstone was deposited on the relatively steep eastern limb of a growth syncline. Outcrops located on steep limbs are rarely preserved in the alpine foreland. In the Grand Coyer Massif, the closure of the depocentre eastwards is still debated. However, new structural and field data, collected between the Sommet de Noncière and Clot de l'Aï (Fig.2a) indicate a strong control of turbidite deposition by NNW-SSE trending folding (Fig. 2e).

The palaeocurrent directions, collected on this area, present two perpendicular directions: (1) toward the NNW, parallel with the calculated fold axis plunge and (2) WSW-ENE directions, which imply current reflection processes of both slopes. Annot Sandstone turbidites were more erosive and incised the Globigerina Marls slope (Fig. 2c-d). At the Sommet de la Frema for instance, this contact has a staircase geometry on the steep limb of a west-verging anticline, visible in the Globigerina Marls and the Nummulitic Limestone (Fig. 2d). Stratigraphic correlation indicates that these turbidites belong to the member F (presence of a heterolithic layer, Fig. 2b-e, named the "vire"). Nevertheless, their interaction with the Globigerina Marls is completely different to at Annot. A more restricted confinement of the turbidite system may explain the observed differences. In narrow conduits, created by secondary folds (Fig. 2e), such as those developed on the eastern limb of the Grand Coyer syncline, turbidite flows will be more erosive than on an open gently dipping limb, such as the Annot depocentre.

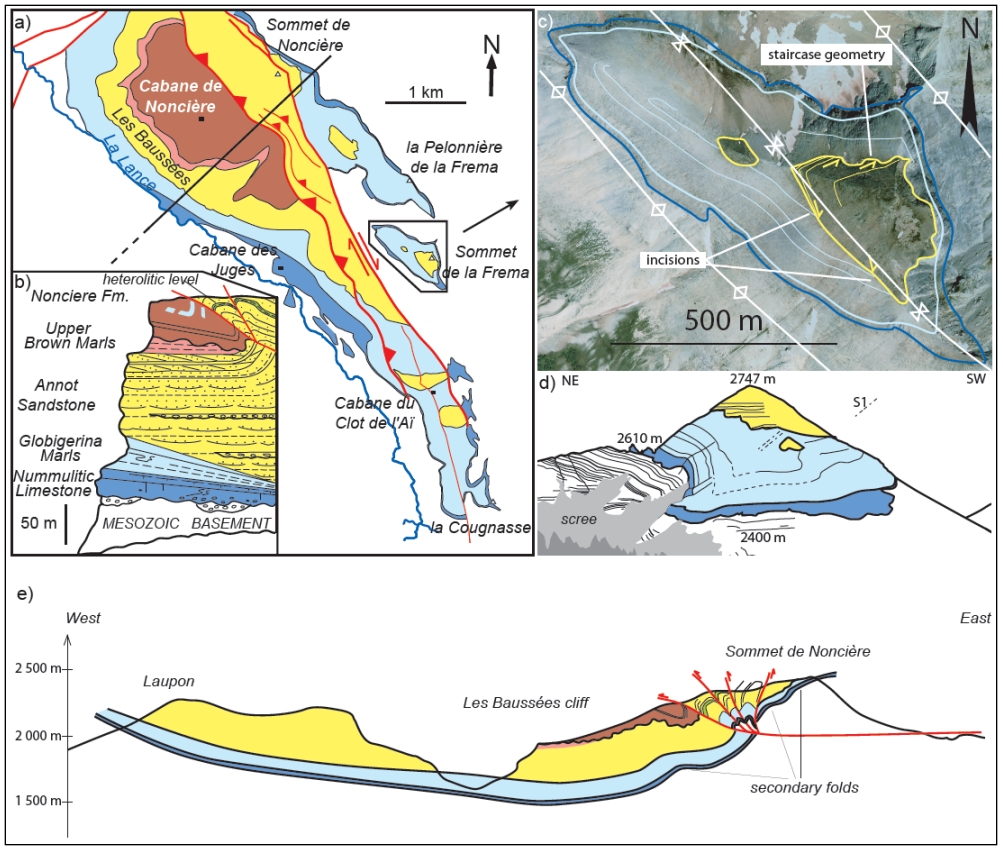

Figure 2 (see figure captions at the end of the text).

Conclusions

Turbidite sedimentation and in particular, its interaction with depositional slope on the limbs of an active asymmetrical syncline can be studied in Annot and Grand Coyer depocentres. In the Annot area, which corresponds to the gently dipping western limb, the depocentre migrated progressively westward under the control of two active fault propagation anticlines, rooted in weak detachment levels. In the Grand Coyer, the secondary folds forming the eastern limb confined the turbidite system. This eastern limb actively uplifted during Annot Sandstone deposition causing more incision in the Globigerina Marls than observed at Annot.

References

Du Fornel, E., Joseph, P., Desaubliaux, G., Eschard, R., Guillocheau, F., Lerat, O., Muller, C., Ravenne, C. & Sztràkos, K. 2004. The southern Grès d'Annot outcrops (French Alps): an attempt at regional correlation. In: *Deep-Water Sedimentation in the Alpine Basin of SE France: New perspectives on the Grès d'Annot and related systems* (Eds P. Joseph and S.A. Lomas), Special Publications, pp. 137-160. Geological Society, London.

Joseph, P. and Lomas, S.A. 2004. *Deep-Water Sedimentation in the Alpine Basin of SE France: New perspectives on the Grès d'Annot and related systems*, Special Publications. Geological Society, London.

Salles, L., Ford, M., Joseph, P., Le Carlier de Veslud, C. and Le Solleuz, A. submitted. Progressive migration of a synclinal depocentre from turbidite growth strata: the Annot syncline, SE France. *Basin Research*.

Figure captions

Figure 1: Vertical thickness maps for Annot Sandstone members (excluding A). These maps are derived from 3D modelling in gOcad. Western pinchout lines for each unit are shown. While member thickness clearly indicates the presence of a NNW-SSE trough for the upper members, thickness variations in the member B are more complex. Deposition of this member has been influenced by the pre-existing but inactive EW Fugeret Anticline (F.A.) and the Braux normal fault (B.F.). Paleocurrent directions are indicated for each member.

Figure 2: a) Structural map of western Grand Coyer. Coulour code in (b). b) Synoptic lithostratigraphy of the Tertiary succession in Grand Coyer. c) Orthorectified photographs of the Sommet de la Frema showing Annot Sandstone onlaps with a staircase geometry and incisions in the Globigerina Marls. d) View toward the SE of the Sommet de la Frema. Notice the staircase geometry of the contact between the Annot Sandstone and the Globigerina Marls. Beddings in the Globigerina Marls and the Nummulitic Limestone are folded by secondary anticline and syncline. e) Cross-section across the Nonciere outcrops showing secondary folds and thrusts. Notice the folded heterolithic layer east of the westernmost thrust.