Zeitschrift: Mémoires de la Société Neuchâteloise des Sciences Naturelles

Herausgeber: Société Neuchâteloise des Sciences Naturelles

Band: 12 (1997)

Artikel: Geology of the central Jura and the molasse basin : new insight into an evaporite-based foreland fold and thrust belt = Géologie du Jura central et du bassin molassique : nouveaux aspects d'une chaîne d'avant-pays plissée et décollée sur des couches d'évaporites

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Kapitel: 6: Conclusions

DOI: https://doi.org/10.5169/seals-100855

6. CONCLUSIONS

Apart from some stratigraphic observations within the Jurassic and Cretaceous layers for which the reader can refer to Chapter 2, the interpretation and correlation of more than 1500 km seismic reflection lines has revealed some major structural elements, which have a considerable consequences for the understanding of the formation of the Jura foreland fold and thrust belt.

This work has confirmed that the cover of the central Jura and the western Molasse Basin has been deformed over a smooth basement surface dipping 1° to 3° to the S-SE, within the limited constraints of seismic resolution. This pre-Triassic basement is not significantly affected by the deformation of structures such as the folds, thrust faults and tear faults observed in the cover. The contrast in deformation between the basement and the cover is due to an unexpectedly thick and very weak décollement zone. This zone, composed essentially of evaporite and salt rocks belonging to seismic Triassic Unit 2 defined in this work (corresponding ± to Middle Triassic age), represents the lowermost seismic stratigraphic unit involved in the deformation of the cover. The regional thickness of this unit ranges from 200 m at the NW periphery of the Jura belt to more than 1000 m in the central part of the Jura, due to structural thickening. Thus Triassic evaporites control the development of the Jura and the Molasse Basin folds during the Late Miocene as well as the arcuate shape of the fold belt.

The analyses of the geometry of structures within the central Jura and the Molasse Basin has shown two types of folds:

1) Evaporite-related folds, located in the Molasse Basin and the external Plateau Jura. The development of these low amplitude buckle folds is related to evaporite stacks within the Triassic Unit 2 layer. The axis of these folds is oriented NW-SE, parallel to the general trend of the Jura belt structures.

2) Thrust-related folds, located within the Haute Chaîne Jura. These high amplitude folds are related to NW- or SW-vergent thrusts of at least kilometric dipslip displacement, that results in a duplication of the entire Mesozoic sequence. These thrusts step up from the main décollement zone (Triassic Unit 2) through the entire Mesozoic and Cenozoic cover series.

These two types of folds are respectively interpreted as embryonic and evolved stages of the Late Miocene cover deformation. The Haute Chaîne Jura folds began as buckle folds, to then evolve into the present thrust-related folds. In the Molasse Basin, however, low amplitude folds represent an early stage which did not evolve because of loading by the overlying thick Tertiary sedimentary wedge. Both types of folds show that the Triassic Unit 2 is clearly involved in the development of fold and thrust structures in the cover of the Jura and controlled their formation.

Furthermore, the cover structures are also influenced by the rheology of the whole stratigraphic column. The increase of the thickness ratio between strong (competent) and weak (incompetent) layers, associated with an increase of the Mesozoic stratigraphic column from the north-eastern towards the south-western Jura, results in the development of low relief box-folds or detachment folds in the eastern Jura and high relief thrust-related folds in the western Jura.

Some seismic lines cross major tear faults which, within the limit of seismic resolution, do not show any significant offset of the basement top from one side to the other. These faults are restricted to the cover and do not present evidence of an offset basement.

In conclusion, interpretation of the seismic lines confirms the "Fernschub" hypothesis concerning the formation of the Jura: the Mesozoic cover of the Jura foreland fold and thrust belt and the Molasse Basin has been pushed to the NW over a main décollement zone. The seismic lines have not shown evidence for inverted Permo-Carboniferous grabens or thrust faults continuing downwards into the pre-Triassic basement. Therefore, the shortening of the basement is compensated, not beneath the Jura, but probably under the external crystalline massifs of the Alps.

This work has provided the opportunity to complete the surface geological observations with subsurface data and thus has allowed to present a regional "three-dimensional view" of basement to cover relationships. Thanks to the subsurface data, new light has been shed on the formation of the Jura, which remains a classical evaporite foreland fold and thrust belt.

ABSTRACT

Geology of the central Jura and the Molasse Basin: new insight into an evaporite-based foreland fold and thrust belt.

More than 1500 km of industry seismic reflection lines in the Neuchâtel and Vaud Jura of Switzerland, the French Jura and the Swiss western Molasse Basin have been interpreted. Through the seismic grid, constrained by drill hole data, each intersection of seismic profiles was controlled in order to obtain an internally consistent interpretation. These new data have shed new light on the stratigraphy of the buried Mesozoic layers and the deformation style of the subsurface structures from the Subalpine Molasse to the external Jura. Interpretation of the seismic lines demonstrates that the Mesozoic and Cenozoic cover of the Jura fold and thrust belt and the adjacent Molasse Basin has been deformed over a weak basal décollement and displaced for many kilometers toward the NW.

Folding and thrusting took place above a very weak décollement zone within the thick seismic Triassic Unit 2 (Middle Triassic age) composed essentially of evaporites, salt and clays. The thickness of this interval ranges from 200 m at the NW periphery of the Jura belt to more than 1000 m in the central part of the Jura. The low amplitude broad folds of the Molasse Basin and the external Plateau Jura are controlled by evaporite pillows or anticlines within Triassic Unit 2. As seen on an isopach map, these structures are aligned along a NE-SW trend parallel to the general trend of the Jura fold and thrust belt. The high amplitude folds of the Haute Chaîne Jura, however, are related to NW- or SE-vergent thrusts with at least kilometric dipslip displacement that result in doubling of the entire Jurassic sequence. These thrusts step up from the main décollement zone through the entire Mesozoic and Cenozoic cover series. The Plateau Jura evaporite-related folds located in the foreland are interpreted as early stage buckle folds. With progressive deformation a fault ramp nucleates and this fold type develops into thrust-related folds as observed in the Haute Chaîne. Thus, within the Jura fold and thrust belt, deformation increases toward the hinterland. In the Molasse Basin, however, low amplitude folds represent an early stage which could not develop further due to load of the overlying thick Tertiary clastic wedge.

The depth to the basement map of the studied area derived from depth conversion of the seismic lines, shows a smooth flat basement dipping 1° to 3° to the S-SE. No significant change in depth and trend of the basement top can be seen below major tear faults which affect the layers of the sedimentary cover. No structural relation can be detected, when comparing isopach map of Triassic Unit 2 series and the basement top contour map. A key conclusion is therefore, that basement is not involved in the formation of folds, thrusts and tear faults in the central Jura and the Molasse Basin.