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## Redefined or not previously defined geological concepts of the pan-European Structural Framework

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## GENERAL INTRODUCTION

This report summarises geological concepts of the GeoConnect³d vocabulary that were defined or redefined and the rationale to do so.

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# 1 CONCEPTS OF THE STRUCTURAL FRAMEWORK

To be able to link the structural framework (SF) of the different project partners, and to provide a hierarchical backbone of the SF, it was decided to develop a pan-European SF. This task, although not foreseen in the project proposal, was considered valuable to improve the understanding of the SF in a more regional view and was developed within WP3 as an additional test of the methodology.

The broadest concepts of the pan-European SF are structured based on partitive modelling, resulting in a thematic subdivision of limits and units (FIGURE 1). These concepts are defined as "collections" of the narrower instances they have.

| Limits |
| --- |
| European plate boundaries |
| European crustal boundaries |
| European deformation fronts |
| European faults |
| European orogenic unconformities |
| European basal unconformities |
| Stratigraphic contacts |
| European lineaments |

| Units |
| --- |
| Plate tectonic units |
| European orogens |
| European massifs and inliers |
| European basins |
| European volcanic deposits |
| European (other) lithostratigraphic units |
| European (other) lithotectonic units |

FIGURE 1: BROADEST CONCEPTS IN THE PAN-EUROPEAN SF, SUBDIVIDING GEOLOGY INTO DEFINED THEMATICS.

The majority of the definitions for these concepts was sourced from the Glossary of Geology (Neuendorf, et al., 2005). However, a few concepts, although commonly used, were not defined there or in other references, including the standard INSPIRE and CGI definitions. And in many cases, concepts were created to group partitively narrowed well-defined concepts.

For instances, definitions have been expanded or slightly modified not only for the pan-European SF, but also for the areas of interest in a minority of cases.

For the reasons above, the GeoConnect³d project suggests the definitions details in the next sections.

# 2 LARGE TECTONIC UNITS

## 2.1 Limits to large tectonic units

Large geotectonic units were defined based on the following limits:

- Plate boundaries: representing boundaries between current tectonic plates and past plates, i.e. suture zones.
- Crustal boundaries: representing the boundary between the continental crust and the oceanic crust within a plate

The ones not previously defined in literature, or of which the definition significantly differs, are the following:

- European plate boundaries: Collection of current plate boundaries and past plate boundaries (suture zones) in Europe
- European crustal boundaries: Collection of continental-oceanic crustal boundaries in Europe

## 2.2 Limited large tectonic units

Large geotectonic units are spatially and contextually defined by their limits, as well as by their conceptual definition. Those not previously defined in literature, or of which the definition significantly differs, are the following:

- Plate tectonic units: Collection of plate tectonic units.
- Paleoplates: Collection of plate tectonic units that have been extensively reworked

# 3 OROGENIES

## 3.1 Limits to orogenies

Interestingly, it is quite difficult to find definitions of the limits of orogenic structures, namely deformation fronts; these are commonly represented in maps, but rarely conceptually defined. For the pan-European SF, the definition of orogenic deformation fronts is characterised and defined as:

Orogenic deformation front: the present or past outermost boundary of an orogen.

This was used to define the deformation fronts, and therefore limits, of the Caledonian, Anglo-Brabantian, Ardennian, Eo-Variscan, Variscan, Alpine Pyreneean and Ural orogenies.

- European deformation fronts: Collection of deformation fronts in Europe. Conceptual aggregation level, not a science-based concept.
- Caledonian deformation front: The outward extents of the deformation events of the Caledonian orogen resulting from the collision between Baltica, Avalonia and Laurentia following the closure of the Iapetus Ocean and Tornquist Sea
- Eastern Caledonian deformation front: Extent of the Caledonian deformation in the continental margins of Avalonia and Baltica to the south and east of the Iapetus suture
- Laurentian Caledonian deformation front: Extent of the Caledonian deformation in the continental margin of Laurentia to the north and west of the Iapetus suture. The front extends from offshore north of Ireland and Great Britain to the southern part of Greenland (Gasser, 2014).
- Baltican Caledonian deformation front: Extent of the Caledonian deformation in the continental margin of Baltica to the northeast of the Tornquist suture
- Avalonian Caledonian deformation front: Extent of the Caledonian deformation in the continental margin of Avalonia to the southwest of the Tornquist suture
- Variscan orogenic front: Outward extents of the Variscan deformation representing the final collision of Gondwana with Laurussia (McCann, 2008).
- Anglo-Brabantian deformation front: The outward extents of the deformation events related to the Anglian and Brabantian orogenies.
- Brabantian deformation front: The Brabantian deformation front is largely time-coeval with the Acadian deformation and geophysically appears even as structurally continuous (cf. Van Grootel et al., 1997), but without necessarily be a direct extension of it.
- Anglian deformation front: The outward extents of the deformation events related to the Anglian orogeny
- Northern Anglian deformation front: The Northern Anglian deformation front is not observed, but is hypothesized to be linked to the Northern Brabantian deformation front
- North-Western Ardennian deformation front: The North-Western Ardennian deformation front is known from observations, but these are fragmented and its interpretation is complicated by the overprint of later Variscan deformation. It is only known from Belgium and observations are lacking to trace it laterally
- Southern Ardennian deformation front: The Southern Ardennian deformation front is not observed and hypothetically assumed to be close to the Rheic suture

- Eo-Variscan deformation front: The outward extents of the deformation events related to the Eo-Variscan orogeny, which resulted from the closure of the Medio-European Ocean in the Late Silurian (Faure et al., 2005).
- Ural deformation front: The outward extension of the deformation related to the Uralides.
- Alpine deformation front: The outward extension of the deformation related to the Alpine Orogen.
- Pyreneean deformation front: The outward extents of the deformation events of the Pyreneean orogen.
- Northern Pyreneean deformation front: The northernmost extent of the deformation events of the Pyreneean orogen.
- Southern Pyreneean deformation front: The southernmost extent of the deformation events of the Pyreneean orogen.

### 3.2 Limited orogenic units

The definitions of the following orogenies and deformation belts have expanded/modified by this project:

- European orogens and nappe systems: Collection of orogens in Europe. Conceptual aggregation level, not a science-based concept.
- Ardennian deformation belt: The Ardennian deformation was defined under that name by Michot (1980, cf. Ardennian Phase), and refers to the pre-Variscan deformation in the Ardennes, which also predates the Brabantian deformation. It is time-coeval with the deformation in the North-German Polish Caledonides, but the deformation belts are too distant to be continuous. The deformation is known from the Ardennes, but its lateral extents are undocumented making it difficult to estimate its regional importance.
- Anglo-Brabantian deformation belt: the result of the inversion of a foreland or intracratonic basin that started in the Silurian, and resulted in a deformed and uplifted belt of rocks that seems to be continuous between the subcrop units known as Brabant Massif and the Anglian Massif, where it is restricted by its deformation fronts.
- Ardenne allochton nappe system: The nappe system named after its basal thrust, the Ardenne basal thrust. The Ardenne is not typically described as a nappe system, although the word 'nappe' is used for individual thrust sheets. The structural interpretation is however compatible with nappe nomenclature, and can be used in parallel with the more traditional subdivisions.
- Brabant autochton: The Brabant autochton are the rocks that are old enough to be deformed by the Variscan orogeny, but show no evidence of ductile deformation or thrusting. The Brabant autochton is therefore positioned adjacent to the Brabant parautochton.

# 4 FAULTS, LINEAMENTS AND RELATED UNITS

## 4.1 Faults and lineaments as limits

The definitions of the following faults have expanded/modified by this project, or are newly introduced:

- European faults: Collection of faults and fault systems in Europe. Conceptual aggregation level, not a science-based concept.
- European transverse faults: Collection of transverse faults. Conceptual aggregation level, not a science-based concept.
- European graben fault systems: Collection of graben fault systems in Europe. Conceptual aggregation level, not a science-based concept.
- European lineaments: Collection of lineaments in Europe. Conceptual aggregation level, not a science-based concept.
- Viersen Fault Zone: the upper northeast fault zone of the Roer Valley rift system.
- Bouhouille Fault: the importance of the Bouhouille Fault depends on the relevance of the Aguesses-Asse Fault. If the Asse Fault is interpreted as the eastward continuation of the Aguesse Fault and not as an individual fault, than the Bouhouille Fault plays an important role in explaining the transverse movement between the Aguesses and Asse faults.
- Ardenne basal detachment: not known from direct observations, but assumed to be the major thrust present at depth, on which the Ardennes allochthon has been transported, and that splays off in different and steeper thrusts that may reach the present-day erosion level.
- Borzée Fault and Jupille Fault: NS trending faults in Belgium that spatially seems to be associated with the Ourthe lineaments.
- Ourthe lineaments (including Eastern and Western): two largely parallel lineaments in Belgium that can be identified at surface level, usually from satellite imagery, and that coincide with a marked change in structural trend. It is therefore assumed that the lineaments represent the surface traces of planes.

## 4.2 Fault and lineament limited units

- European grabens: Collection of grabens in Europe. Conceptual aggregation level, not a science-based concept.
- Ourthe zone: NS trending zone, mainly visible in the Ardennes Allochthon (Belgium), in which the structural grain of the Ardennes shifts or is perturbed. In some places this is associated with important quartz veins.
- Cenozoic and Mesozoic system: Collection of European lithotectonic units in the European Cenozoic and Mesozoic rift system expanding from the North Sea coast to the Mediterranean (over 1100 km) developed due to a directed extensional phase to the north of the Alpine orogenesis since the late Eocene.

# 5 UNCONFORMITIES, CONTACTS AND RELATED UNITS

## 5.1 Unconformities as limits to basins and lithostratigraphic units

The definitions of the following faults have expanded/modified by this project:

- European orogenic unconformities: Collection of orogenic unconformities in Europe. Conceptual aggregation level, not a science-based concept.
- European basal unconformities: Collection of basal (i.e. basin defining) unconformities in Europe. Conceptual aggregation level, not a science-based concept.
- Paris Basin Unconformity: The Paris Basin Unconformity is the surface marking the gap between flat-lying, gently south-dipping Triassic-Jurassic rocks that unconformably cover the southern limb of the Ardenne Allochthon, including the southern limb of the Variscan Eifel Depression which is part of the High-Ardenne slate belt, which itself is part of the Ardenne Allochthon (Cambier & Dejonghe, 2010). There is a distinction between the unconformity of the Mesozoic cover on top of Lower-Paleozoic inliers like Rocroi and Givonne and the cover on top of the Lower-Devonian Ardennes.
- European contacts: Collection of contacts in Europe. Conceptual aggregation level, not a science-based concept.
- Stratigraphic contacts: Collection of stratigraphic contacts. Conceptual aggregation level, not a science-based concept.
- Intrusive contacts: Collection of intrusive contacts. Conceptual aggregation level, not a science-based concept.
- Impact structure contacts: Collection of contacts caused by impact structures. Conceptual aggregation level, not a science-based concept.

## 5.2 Unconformity or contact limited basins and lithostratigraphic units

For basins and lithostratigraphic units, the following definitions have expanded/modified by this project:

- European basins: Collection of sedimentary basins in Europe. Conceptual aggregation level, not a science-based concept.
- European carbonate basins: Collection of carbonate basins in Europe. Conceptual aggregation level, not a science-based concept.
- European (other) lithostratigraphic units: Collection of uncategorised lithostratigraphic units. Conceptual aggregation level, not a science-based concept.
- European massifs and inliers: Collection of massifs and inliers in Europe. Conceptual aggregation level, not a science-based concept.
- European magmatic rocks: Collection of European magmatic rocks. Conceptual aggregation level, not a science-based concept.
- Volcanic deposits: Volcanic centers and volcanic deposits resulting from volcanic activities of diverse ages. Conceptual aggregation level, not a science-based concept.
- Intrusive rocks: Collection of intrusive rocks. Conceptual aggregation level, not a science-based concept.

- Liège basin: can refer to a carbonate subbasin, or in a more pragmatic sense to the part of the North-West European coal basin around Liège.
- Devonian carbonates: Carbonate deposits of Middle-Devonian age in Belgium.

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