Chapter 1
Introduction

1.1 The continental crust's involvement in the orogenic processes

The reconstruction of the collisional belt history includes the study of different steps of the convergence between two tectonic plates. After the subduction of the oceanic lithosphere, the progressive underthrusting of the passive margin beneath the wedge occurs simultaneously with the evolution of the foreland basins. Foreland basins represent a first-order tectonic element in the framework of collisional belts (e.g., Allen et al. 1986). They originate during the first stage of the collision when a passive margin collides with an active continental margin after the closure of an oceanic basin by subduction/obduction processes. The foreland basins continue to develop in front of the advancing wedge also during the mature stage of the collision and progressively become incorporated within it (e.g. Beaumont 1981).

Regarding the underthrusting of continental crust, several modeling studies have shown the various conditions that can make continental crust prone to subduction (Cloos 1982; Chemenda et al. 1995; 1996; Ernst 2001; Burov et al. 2014), and several evidences from exhumed orogens show that continental crust can be underthrust down to depths > 50 km so that they deform under eclogite facies, giving rise to high-pressure and ultra high-pressure (HP and UHP, respectively) units (Chopin 1984; Dewey et al. 1993; Chemenda et al. 1996; Compagnoni and Rolfo 2003; Ernst 2001; 2005; Guillot et al. 2009; Lanari et al. 2012). The exhumation of HP an UHP rocks is a transient process occurring during continental subduction and continental collision (Ernst 2001; Agard et al. 2009; Strzerzynski et al. 2012; Schmalholz et al. 2014). As for HP oceanic units, the vertical movement of continental slices from depth up to the surface is far to

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be clearly understood, and different mechanisms have been proposed for the exhumation of HP and UHP units in orogenic belts, including the "classic", but worthy to note models such as channel flow (Cloos, 1982), corner flow (Platt 1986), extensional collapse (Dewey et al. 1993), thrusting onto the foreland (Steck et al., 1998), buoyancy through erosion and tectonic processes (Chemenda et al. 1995), ductile extrusion (Chemenda et al. 1996; Gerya et al. 2002, 2008), compression of a soft zone between two rigid blocks (Thompson et al. 1997), serpentinite channel (Guillot et al. 2001), and coaxial extension associated with a decoupling fault (Jolivet et al. 2003). The development of different tectonic regimes during continental subduction depends on factors such as the pull force, the plate convergent rate and the geothermic gradient, that can change dramatically when continental crust enters the subduction zone and, progressively, during the proceeding of continental subduction. Consequently, the style of deformation, the metamorphic conditions and the exhumation mechanisms of HP continental rocks can change with time even in a single margin. The diverse possible mechanisms of exhumation developed through different thermomechanical processes testify the critical role of deciphering the kinematic evolution and dating the metamorphic history of HP continental units in orogenic belts (e.g. Guillot et al. 2009).

In this framework, the interaction of the subducting continental crust with the oceanic units already accreted to the wedge must be take into account. Although the underthrusting and the subsequent underplating of the oceanic lithosphere predates the continental subduction, a common exhumation path of the continental and oceanic units from the shallow depths to the surface could not be excluded.

1.2 Studying the Alpine Orogeny in Corsica

The Alps are a collisional belt where the foreland basin and the paired thrust wedge migrated for ~150–200 km in an approximately stable manner over the lower continental plate, leading to an inversion of a foreland basin, and its deformation by out-of-sequence thrusts (Sinclair 1997). This picture can be extended also to the Corsica island, where the southern continuation of the Alpine collisional belt has been recognized since long time (e.g. Mattauer et al. 1981).

From the geological point of view, the Corsica Island is divided into two domains, known as Hercynian and Alpine Corsica (e.g. Durand-Delga 1984), which extend in the south–west and north–east areas, respectively. The tectonic boundary between these two domains runs across the island with NNW–SSE strike along which the tectonic units of Alpine Corsica are thrust onto Hercynian Corsica. Hercynian Corsica is representative of a continental domain of the European plate whose eastern border played the role of the foreland domain during the continental collision. It consists of metamorphic basement with

Panafrican and Variscan metamorphic imprint and intruded by magmatic rocks of Permo–Carboniferous age (Ménot 1990; Laporte et al. 1991; Paquette et al., 2003; Rossi et al. 2009). This basement is covered along its eastern border by Mesozoic carbonates unconformably topped by siliciclastic turbidites of Tertiary age. In contrast, the Alpine Corsica consists of a complex stack of continental and oceanic units of a variable degree of metamorphism from very low-grade to blueschist-eclogite facies (e.g. Mattauer et al. 1981; Durand-Delga 1984). As in the Western Alps, the units with continental affinity are overthrust by oceanic and transitional units, referred to as the Schistes Lustrés Complex (Gibbons et al. 1986; Caron 1994; Levi et al. 2007; Vitale Brovarone et al. 2012).

The continental units (i.e. the Lower Units) crop out along a north-south trending strip at the western border of the Alpine Corsica, and are regarded as fragments of the thinned European margin (Durand-Delga 1984; Caron 1994; Malasoma et al. 2006; Molli et al. 2006; Di Rosa et al. 2017a) that underwent Early Tertiary continental subduction, and subsequent syn-convergent exhumation, as a result of the closure of western Tethys (Amaudric Du Chaffaut and Saliot 1979; Bezert and Caby 1988; Caron 1994; Tribuzio and Giacomini 2002; Malasoma and Marroni 2007; Molli 2008).

However, differently from Western and Central Alps where the continental collision tectonics is still active in the Quaternary, the advance of the Alpine wedge in Corsica is frozen at the Oligocene-Miocene boundary (Rehault et al. 1984; Jolivet et al. 1990; Fournier et al. 1991; Brunet et al. 2000), when the opening of the Liguro-Provençal and the Tyrrhenian Basins isolated the Alpine Corsica from the neighboring domains of the Alpine collisional belt with consequent stop of the collisional shortening (Doglioni et al. 1998; Mauffret et al. 1999; Fellin et al. 2005).

In a general view, the Hercynian Corsica is regarded as a single area unaffected by deformation and metamorphism during the Alpine tectonics, thus representing a foreland domain never underthrust by the orogenic wedge (Durand-Delga 1984), whereas the Alpine Corsica is considered the rest of the convergence between Europe and Africa, formed between the Late Cretaceous and the Miocene time lapse. In this framework, the exhumation of the Lower Units led the authors to apply the models proposed for the Alps to the Corsica Island. First, the local/lithospheric-scale extension in a thrust wedge setting (Platt 1986; England and Houseman 1989) has been proposed (Jolivet et al. 1990; 1991; Fournier et al. 1991; Daniel et al. 1996). Subsequently, the "nappe intrusion mechanism" of Escher and Beaumont (1997) was adopted by Malavieille et al. (1998). In this model, the continental crust involved in the subduction zone were detached from the downgoing slab because of the buoyancy forces and shearing. These supra-crustal rocks, lighter than the surrounding mantle, went up while the denser lower crust continued to be subducted. The syn-subduction rise of slices of upper crust leads the rapid exhumation of HP/LT rocks and the development of normal faulting zone along the upper surface of the rising body.

Deepening the study of some transects between the Hercynian and the Alpine

Corsica, several problems to the general model arise. The presence of Alpine deformation and metamorphism which locally affects the Hercynian Corsica has been observed. As regards the Alpine Corsica, the simultaneous exhumation of oceanic and continental units from shallow depths to the surface has been verified. Although local studies on the deformation of the Hercynian Corsica occur (e.g. Amaudric du Chaffaut 1980), its interpretation in the geodynamic evolution of the Alps is missing, as well as a comparison between the tectono-metamorphic history of the continental and oceanic units, so far studied separately (e.g. Malasoma and Marroni 2007; Vitale Brovarone et al. 2012).

1.3 Thesis outline

At the state of art, the study of the orogenic processes consists in connecting a wide range of data in order to constrain the behavior of the continental crust during the different stages of convergence. This thesis is aimed to reconstruct the Alpine cycle evolution of the European margin located in Corsica, focusing on (1) the effects of the orogeny on the foreland, (2) the behaviour of the portion of the continental margin involved in subduction and (3) the complex exhumation of the continental units that followed independent paths until the late stage, when the coupling with the oceanic units occur. The work is subdivided into two stages that describe the pre-collision setting, i.e. the stratigraphic features of the continental units, and the orogeny itself, i.e. the Middle to Late Eocene deposition of the forebulge deposits, the Late Eocene subduction and syn-convergent exhumation of part of the European-derived units, the simultaneous localization of deformation within the European margin and the Early Oligocene switching from compression to (transpression/) extension.

The study area is located in the western side of the Alpine Corsica between Asco and Fium'Orbo Valleys, and roughly covers the rim between the Hercynian and Alpine Corsica. Within this wide area, which has an extension of about 1200 km^2, six sites have been studied in detail (Asco, Cima Pedani, Corte, Venaco, Noceta and Ghisoni), in order to characterize the lithostratigraphy, the deformation mechanisms and the tectono-metamorphic history of the rocks belonging to the Hercynian and Alpine Corsica. Particular attention was paid to the Lower Units, that represent the portion of the European plate involved in the processes of subduction and exhumation during the Alpine Orogeny. The stratigraphic relations of the Lower Units with the foreland (i.e. the Hercynian Corsica), as well as the comparison of the tectono-metamorphic data of the Lower Units with those related to other units belonging to the Alpine Corsica (i.e. Schistes Lustrés Complex) are also discussed.

The results of a detailed map- to microstructural analysis and tectono-metamorphic studies conducted on the Lower Units and on the Schistes Lustrés Complex and the Hercynian Corsica in proximity of the Lower Units are collected for this thesis. The field activity is summarized in the structural maps and integrated with estimation of the P-T conditions associated to the Lower Units deformation, of the age of the emplacement of magmatic rock and the age of the rifting, obtained through different laboratory techniques (all the methods are described in the supplementary materials).