Journal of Geodynamics 66 (2013) 65–78

Contents lists available at SciVerse ScienceDirect

Journal of Geodynamics

journal homepage: http://www.elsevier.com/locate/jog

Current tectonic activity and differential uplift along the Cottian Alps/Po Plain boundary (NW Italy) as derived by PS-InSAR data

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ARTICLE INFO

Article history:
Received 12 September 2012
Received in revised form 18 January 2013
Accepted 3 February 2013
Available online 20 February 2013

Keywords:
PS-InSAR interferometry
Current tectonics
Western Alps
Northern Apennines
Seismotectonics

ABSTRACT

Iso-Kinematic maps have been derived from spatial statistics (Hot Spot and geostatistical analysis) of Permanent Scatterers Interferometric Synthetic Aperture Radar (PS-InSAR) data, and compared with geological, geomorphological, seismological and GPS data in order to analyse the current tectonics and the crustal mobility, at the boundary between the Cottian Alps and the Western Po Plain. This area corresponds to the subsurface junction between the Western Alpine chain and the Northern Apennines.

PS data show that the Western Alps are currently uplifting with respect to the adjoining Western Po Plain, as confirmed by the GPS data. The Iso-Kinematic Boundary between these two sectors partly coincides with a regional N–S fault system developed along the inner seismogenic border of the Cottian Alps. Focal mechanisms indicate transpressive movements along this Iso-Kinematic Boundary, which separates two domains characterized by different fault geometry and kinematics, namely: (a) the Cottian Alps, where N–S transtensive/normal faults have developed, and (b) the subsurface Western Po Plain, where NW–SE transpressive/reverse faults are dominant.

This articulated tectonic setting results from the complex strain partitioning of the oblique convergence between the European and Adria plates, which is still ongoing, as indicated by seismotectonic and geodetic data.

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1. Introduction

The westernmost Po Plain, south of Turin, masks at surface the deep indentation of the Alpine and Apennine orogenic belts. The Alps–Apennines junction zone, which is subjected to moderate differential uplift, as observed by GPS data (Devoti et al., 2011), is affected by low magnitude instrumental seismicity ($M_L < 5$) despite the fact that historically, earthquakes that have struck this area have reached up to a moderate magnitude (seismic event of April 2, 1808, $Ms = 5.5$; Boschi et al., 2000).

Some studies (Delacou et al., 2004, 2008; Perrone et al., 2010, 2011b; Sue et al., 2007; Sue and Tricart, 2003) have served to shed new light on the seismotectonics of the Western Alpine chain, but further investigations are required to fully understand its relationship with the current tectonics of the adjoining Western Po Plain, where information regarding the active tectonics is scarce.

Due to its geological complexity, low magnitude seismicity and lack of evidence of Quaternary deformations, the more recent seismotectonic interpretations for this area had to be based on the results of multidisciplinary studies (Perrone et al., 2010, 2011b) in which different datasets (geological, structural and seismological) were merged and compared.

Recently Morelli et al. (2011) used PS-InSAR interferometry data to constrain the analysis at a regional scale of the tectonic mobility of low deformation settings, such as the study area. Continuous PS-velocity surface maps (Iso-Kinematic Maps: IKM), obtained from spatial statistics of interferometry data (Hot Spot and geostatistical analysis), were used for direct comparison of PS-InSAR data with the geological maps, through the individuation of PS kinematically homogeneous domains, regardless of absolute PS-velocity values, and characterization of the boundaries between them (Iso-Kinematic Boundaries). When Iso-Kinematic Boundaries correspond with known geological features, they can be used to constrain seismotectonic or regional kinematic models. In the case

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http://dx.doi.org/10.1016/j.jog.2013.02.004

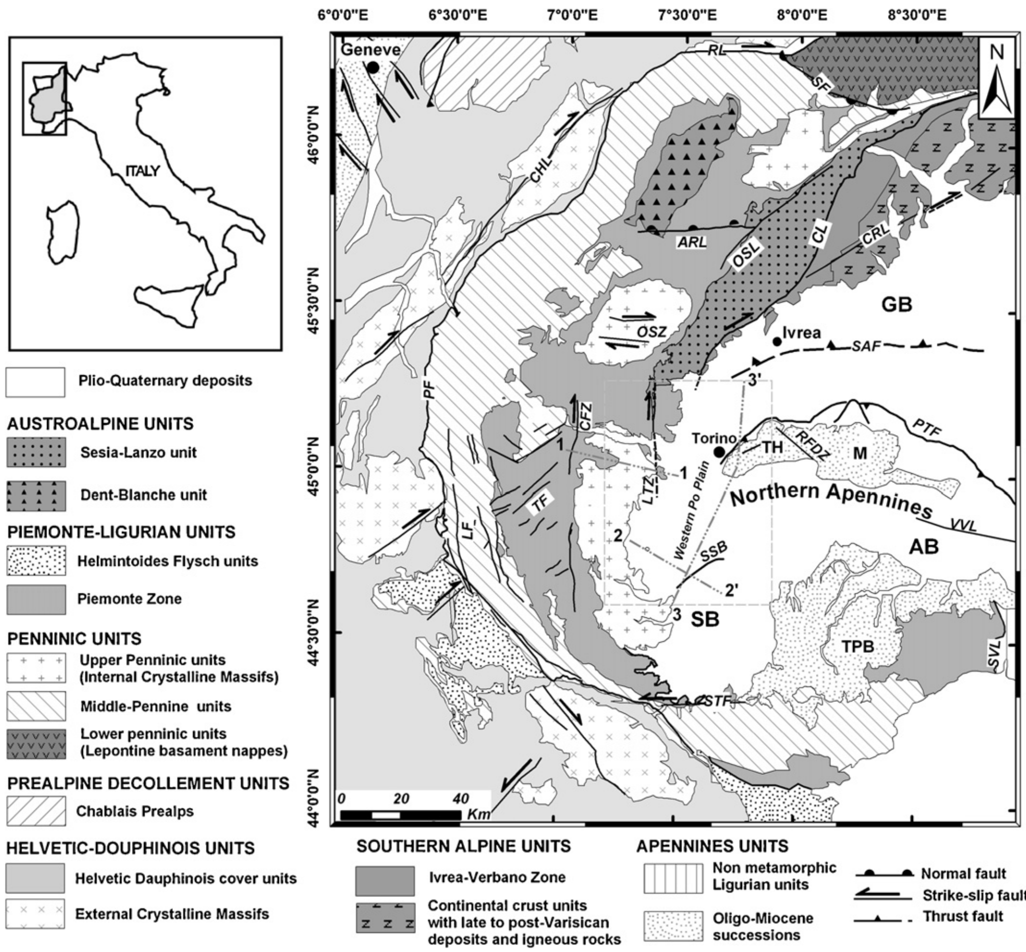

Fig. 1. Tectonic sketch of the Western Alps. The dashed rectangle shows the study area. AB: Alessandria Basin; GB: Gonfolite Basin; M: Monferrato; SB: Savigliano Basin; TH: Torino Hill; TPB: Tertiary Piemonte Basin; ARL: Aosta-Ranzola Line; CFZ: Colle delle Finestre Deformation Zone; CHL: Chamonix Line; CL: Canavese Line; CRL: Cremosina Line; LF: Longitudinal fault system; LTZ: Col del Lis-Trana Deformation Zone; OSL: Ospizio–Sottile Line; OSZ: Orco Shear Zone; PF: Penninic Front; PTF: Padanian Thrust Front; RFDZ: Rio Freddo Deformation Zone; RL: Rodano Line; SAF: Southern Alpine Thrust; SF: Simplon Fault; SSB: Saluzzo–Sommariva del Bosco Thrust; STF: Stura Fault; SVL: Sestri–Voltaggio Line; TF: Transverse Faults; TL: Tonale Line; VVL: Villalvernia–Varzi Line. After Bigi et al. (1990).

that IKB do not correspond with known geological features, it can be suggested that: (i) IKB could have originated as a result of non-geological factors or (ii) new geological models could be envisaged to fit with the PS-InSAR data.

In this study, PS-InSAR data have been statistically analysed to generate IKM of the inner Cottian Alps (between the Stura di Lanzo and Po valleys) and the Western Po Plain (Fig. 1). These new IKM have been compared with the available geological, structural, geomorphological, seismological and GPS data to study the relationship between differential uplift, crustal mobility and the current tectonic activity of this sector. This study contributes to improving the knowledge of the current tectonic activity in the Western Po Plain and provides some new constraints for the recently outlined seismotectonic model (Perrone et al., 2010, 2011b) of one of the most populated areas of Northern Italy.

2. Geological framework

The study area includes the inner sector of the Cottian Alps (Italian Western Alps) and the subsurface western termination of the Northern Apennine chain which is masked at surface by the fluvial deposits of the Western Po Plain (Fig. 2). In the following section, the major brittle structural features and the post-Oligocene tectonic evolution of these two domains will be briefly reviewed. Subsequently, the Quaternary evolution of the Western Po Plain will be analysed.

2.1. The inner Cottian Alps

The Cottian Alps consists of a nappe stack constituted by oceanic and continental units belonging to the Penninic and Austroalpine Domain (Figs. 1 and 2). These units were tectonically superposed during the Alpine orogenic cycle and underwent high pressure/low temperature metamorphic conditions during subduction, followed by greenschists re-equilibration during continental collision (Polino et al., 1990 with references). Available apatite and zircon fission track data indicate that, since the Oligocene, these tectonic units were exhumed at shallow crustal levels (<10 km) and displaced by a complex fault network (Balestrieri et al., 2004; Bernet et al., 2001; Cadoppi et al., 2002; Malusà et al., 2005; Perrone et al., 2011a; Tricart et al., 2007).

The major semi-brittle to brittle faults affecting this part of the Alpine chain, from the inner to the external sector (from East to West), correspond to (i) the Col del Lis-Trana Deformation Zone (LTZ) and (ii) the Colle delle Finestre Deformation Zone (CFZ). Between these regional discontinuities other minor faults are also present.

The Col del Lis-Trana Deformation Zone (LTZ in Figs. 1 and 2) corresponds to an N–S, sub-vertical structure that runs from the

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