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Structural style of the Okcheon fold-thrust belt in the Taebaeksan Zone, Korea

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ABSTRACT

Structural interpretation of the distinct map pattern defined by highly connected thrust traces in the map view of the Taebaeksan Zone provides insight into the structural style of the northeastern Okcheon Belt. The map pattern can generally be explained by either a folded imbricate fan or a hinterland dipping duplex. The same geometry could also be formed by a complex combination of major imbricate thrusts and their connecting splays, having the structural architecture of a typical fold-thrust belt. However, a folded imbricate fan model is not adequate to explain the absence of late Paleozoic to early Mesozoic strata (i.e. the Pyeongan Supergroup) between two major thrusts (viz. the Pyeongchang and Machari thrusts) in this area. This result further suggests that the Yeongwol area, the western part of the Taebaeksan Zone, is a duplex that corresponds to a more internal and deeper hinterland part of the fold-thrust belt, while the imbricate thrusts with low connectivity in the Taebaek area, the eastern part of the Taebaeksan Zone, indicate a more external and shallower foreland portion of the belt. In addition, cross-cutting relations and newly obtained sensitive high-resolution ion microprobe (SHRIMP) U–Pb zircon ages from a cross-cutting dike and syntectonic sedimentary rocks suggest limited thrust reactivation after the early Jurassic and early Tertiary, respectively. In spite of this, the original geometry of the fold-thrust wedge in the Taebaeksan Zone remained well preserved.

1. Introduction

Fold-thrust belts are a distinctive feature of orogens developed at convergent plate boundaries (e.g. Dahlstrom, 1970; Elliott and Johnson, 1980; Boyer and Elliott, 1982; Diegel, 1986; Srivastava and Mitra, 1994; DeCelles and Mitra, 1995; Kwon and Mitra, 2004; Kwon et al., 2007; Mitra et al., 2010). Significant shortening within fold-thrust belt is accommodated by transferring slip along the thrusts (Dahlstrom, 1970; Suppe, 1983; Mitra, 1990, 1997; Suppe and Medwedeff, 1990; DeCelles and Mitra, 1995; DeCelles et al., 2002; Kwon and Mitra, 2004, 2006). Thrusts represent major elements of orogenic belts, and are classified into two distinct systems (i.e. duplex vs. imbricate fan) (Boyer and Elliott, 1982). The duplex system is generally found in internal and deeper hinterland portions of a fold-thrust belt, while the imbricate fan is commonly developed in external and shallower forelands (Boyer and Elliott, 1982; Mitra and Sussman, 1997; Mukul and Mitra, 1998; Kwon and Mitra, 2006; Bhattacharyya and Mitra, 2009; Mitra and Bhattacharyya, 2011). Duplexes and imbricate fans have distinct three-dimensional structural relations between thrusts that can be defined by the geometric relations of combined branch lines, tip lines, and cutoff lines (Boyer and Elliott, 1982; Diegel, 1986). Erosion through the branch lines of a duplex generally produces closed-loop map patterns of highly connected thrust traces. In contrast, erosion through tip lines of imbricate thrusts results in fault traces with low connectivity on map views (Boyer and Elliott, 1982; Diegel, 1986; Mitra and Sussman, 1997; Bhattacharyya and Mitra, 2009). However, an imbricate fan that is folded into an antiformal culmination or synformal depression due to underlying thrusts can also produce a closed-loop map pattern similar to that of a duplex, emphasizing the importance of analyzing thrusts in three dimensions (Boyer and Elliott, 1982; Diegel, 1986; Jamison, 1987).

The Okcheon Belt, together with the Imjingang Belt, has been suggested to be a prominent fold-thrust belt with thrusts and related folds (Cluzel et al., 1991; Kim, 1996; Chough et al., 2000) (Fig. 1a). It is divisible into a Paleozoic Taebaeksan Zone in the northeast and a Neoproterozoic to Paleozoic Okcheon Zone in the southwest (Fig. 1a). The belt, in general, has more preserved evidence of polyphase ductile deformation in the Okcheon Zone than in the Taebaeksan Zone (e.g. Reedman and Um, 1975; Cluzel et al.,

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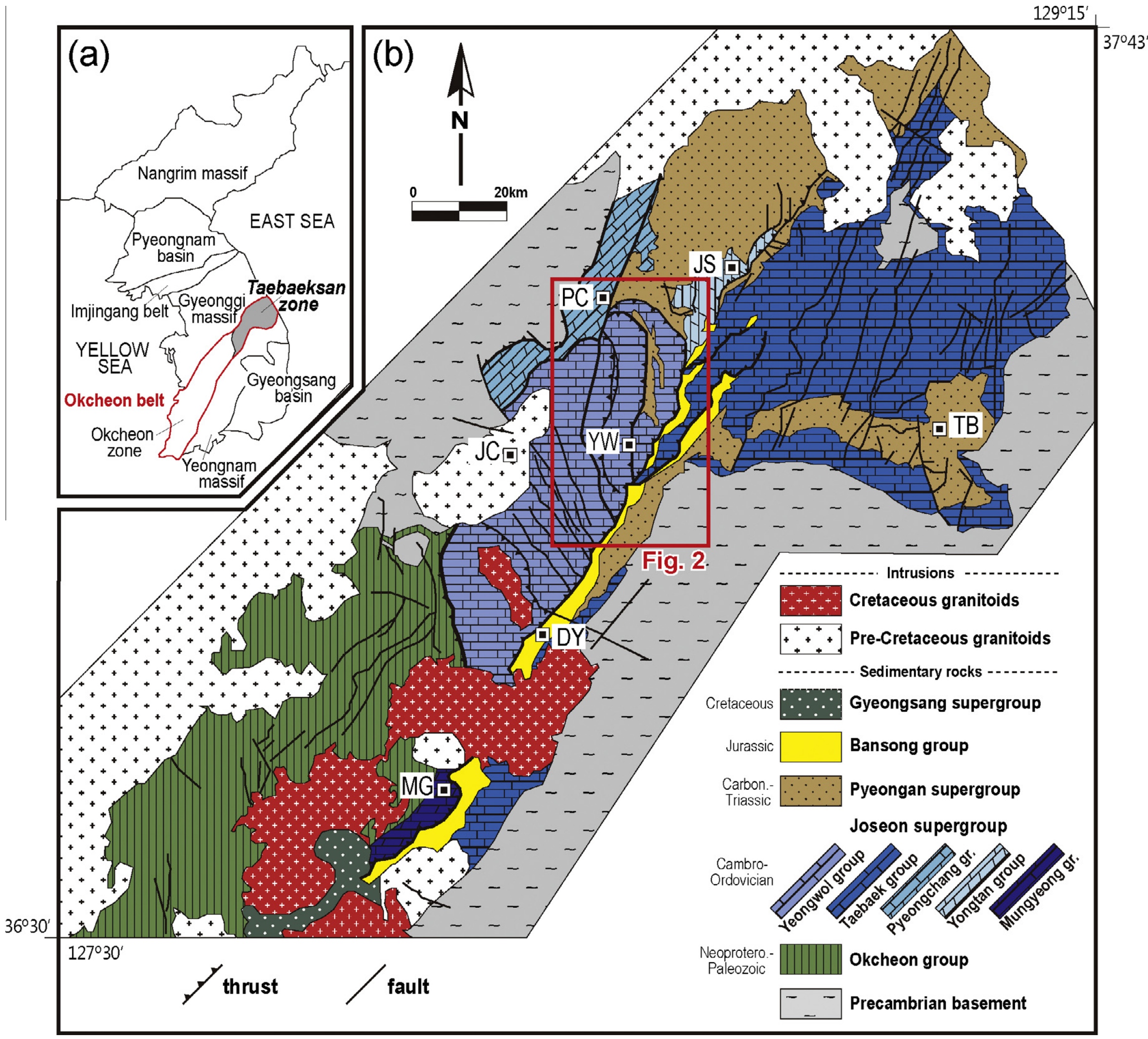

Fig. 1. (a) Regional tectonic map of the Korean Peninsula (modified after a 1:1,000,000 tectonic Map of Korea; KIGAM, 1995). (b) Geological map of the northeastern Okcheon Belt (modified after GICTR, 1962; Kim et al., 2001; Ree et al., 2001). DY – Danyang; JC – Jecheon; JS – Jeongseon; MG – Mungyeong; PC – Pyeongchang; TB – Taebaek; YW – Yeongwol. Inset box indicates the location of Fig. 2.

1990, 1991; Kim, 1996; Ree et al., 1996, 2001; Chough et al., 2000). Based on a biogeographic correlation of Paleozoic faunas in the Taebaeksan Zone, the area was interpreted either to reflect changes in the sedimentary environment on a single continental shelf (Choi and Kim, 2006; Choi, 2009; McKenzie et al., 2011) or to have been deposited before the Triassic on two different continental blocks (i.e. North and South China blocks) (Kobayashi, 1966, 1967), suggesting a possible tectonic event akin to the Qinling–Dabie–Sulu collision belt of China (Chough et al., 2000; Ree et al., 2001). In addition, differences in sensitive high-resolution ion microprobe (SHRIMP) U–Pb ages of detrital zircons from the Pibanryeong and Poeun units of the Okcheon Zone are also interpreted as evidence of suturing of Paleozoic terranes as a consequence of the Permo–Triassic collision of the North and South China blocks (Cho et al., 2013).

Within the Taebaeksan Zone, the Yeongwol area provides a unique exposure of highly connected thrust traces with NW-SE to N-S traces that differ from the overall NE structural trend of the Okcheon Belt (Fig. 1b). We studied the three-dimensional geometry of the Yeongwol area to constrain the structural evolution of the Taebaeksan Zone. We also performed SHRIMP U–Pb zircon age dating on an igneous intrusion and sedimentary rocks. Our results, together with cross-cutting relationships, indicate the late reactivation of earlier structures resulting in the present-day structural geometry of the Yeongwol area. The results also point toward much broader implications on how detailed structural studies in three dimensions can aid in the interpretation of the tectonic evolution of initial sedimentary basins.

2. Geological setting

2.1. Tectonic framework

The Okcheon Belt in the south-central part of the Korean Peninsula is an overall NE-SW trending fold-thrust belt bounded by the Precambrian Gyeonggi massif to the north and the Yeongnam massif to the south (Fig. 1a). The belt is separated into the Okcheon and Taebaeksan Zones (Fig. 1a), which represent different metamorphic conditions and deformation features. The Okcheon Zone consists of metasedimentary and metavolcanic rocks of late Proterozoic to early Mesozoic ages that have experienced several episodes of metamorphism and deformation (Chough et al., 2000). The Taebaeksan Zone consists of weakly metamorphosed sedimentary rocks of Paleozoic to early Mesozoic ages. The entire belt has intrusions of Mesozoic granitoids (Fig. 1b) of continental-arc origin (Sagong et al., 2005).