英 Mountain building mechanisms in the Southern Central Range of the Taiwan Orogenic Belt — From accretionary wedge deformation to arc – continental collision

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Abstract

Most researches consider the Taiwan Orogeny to be the result of an oblique arc-continental collision between the Philippine Sea Plate and Eurasia Plate. According to kinematic modeling, the mountains started to build from the north and progressively propagated southward at a rate of 60-90 km/my. Because of the oblique nature of the collision, the influence of the collision on mountain building resulted in the southern Central Range experiencing orogenic processes more recently than in the north. In order to test this model, we studied a critical area using zircon and apatite fission-track data to reveal the early uplift history of the southern Central Range. We find that uplift started about 6 Ma, which is earlier than the previously predicted timing of mountain building. We also find that the uplift history can be separated into two stages: an initial stage starting at ca. 6 Ma and continuing to ca. 1 Ma with a slow uplift rate of <1mm/yr; and a second stage starting at ca. 1 Ma until the present with a high uplift rate of 4-10 mm/yr. The initial stage of mountain building is considered to be related to accretionary wedge deformation as the South China Sea Plate subducted beneath the Philippine Sea Plate whereas the second stage mountain building resulted from the arc-continental collision. Combining the ages of isotopic dating and fission-track dating in the northern Central Range, we find that the northern Central Range also started uplifting at ca. 6 Ma and that its uplift history can also be separated into two stages with similar uplift patterns and mechanisms to that of the southern Central Range. The most notable difference between the uplift history of the northern and southern areas of the range is the more extensive degree of exhumation in the north; this could be attributed to the northern Central Range having experienced a longer collision history.

Introduction

Most researches consider Taiwan Orogeny to be the result of an oblique collision between the Luzon arc and the passive continental margin of the Eurasia plate. The Luzon arc trends N-S on the Philippine Sea plate and the Eurasia continental margin is NE trending. The Philippine Sea plate moves NW at 7-8 cm/yr (Yu et al.,1997) resulting in a collision starting in the north and progressively propagating southward (Suppe, 1981; 1984; Teng, et al.,1990; Hwang et al.,1997). According to different geometric boundary conditions, different researches have concluded varying rates of southern propagation from 60-90 m/my (e.g., [Suppe, 1981; Hwang, 1997;Liu et al.,2001; Malavieille et al, 2001]) (Fig.1). In addition, different kinematic modeling has given different estimates of the timing of the arc-continental collision; these are as follows: 2-3 Ma for Malavieille et al., (e.g., [8]), 4 Ma for Suppe (Suppe, 1984), 5-3 a for Teng (Teng, 1990), 6-4 Ma for Barrier and Angelier (Barrier and Angelier , 1986), and Hwang et al., (Hwang et al.,1997). However, regardless of the variety of estimates in the southern propagation rate and timing of the collision all these models indicate the southern Central Range of Taiwan starting its collision and mountain building more recently than the northern range. The seismological data show the collision occurring to the north of Taitung and the South China Sea Plate subducting the Philippine Sea Plate to the south of Taitung (Wu et al., 1997; Kao et al., 2000) (Fig.1). By contrast, Lin and Watt (Lin et al.,2002) found the initial timing of the foreland basin's development to be ca. 6.5 Ma from the north to south of Taiwan. The development of the foreland basin results from the load on the orogenic belt. Consequently, the age of the foreland basin can also indicate the timing of mountain building. Their study shows the initial timing of mountain building is roughly the same from north to south.

In order to reveal the cooling and exhumation history, we use a low temperature thermochronometry method, zircon fission-track dating, to reveal the initial timing of mountain belt formation. Whilst a good deal of zircon fission-track dating has been done previously on Taiwan orogenic belt, most of the dating has concentrated on the mid-part of the Central Range (Liu et al., 2001; Willett et al.,2003). The mid-part of the Central Range is in a steady-state of exhumation, and hence zircon fission-track-data ages range from 1.5~3 Ma (Liu et al., 2000; Willett et al., 2002) and the initial timing of mountain building cannot be inferred from this data (Wangner et al., 1972). In the southernmost region of the Central Range, the metamorphic grade progressively decreases from north to south, from green schist facies to prehnite-pumpellyite facies, and then to zeolite facies and the strata are also progressively younger from north to south (Chen, 1998) (Figs. 2 and 6). In order to conduct our study an appropriate study area, where zircon fission tracks had been totally reset, needed to be determined; and this area would be near the boundary of total reset and partial reset of zircon fission tracks. For such an area, the total exhumation amount should not be too large and zircon fission-track aging could record the oldest reset ages and reflect closely the timing of initial uplift. As a result, we chose the transect from Sandiman to Taimali, an expanse located near the southern boundary of the total reset area for zircon and where metamorphic grade is of low green-schist face, which is only slight higher than the reset temperature of zircon, 235±20°(Chen, 1998).

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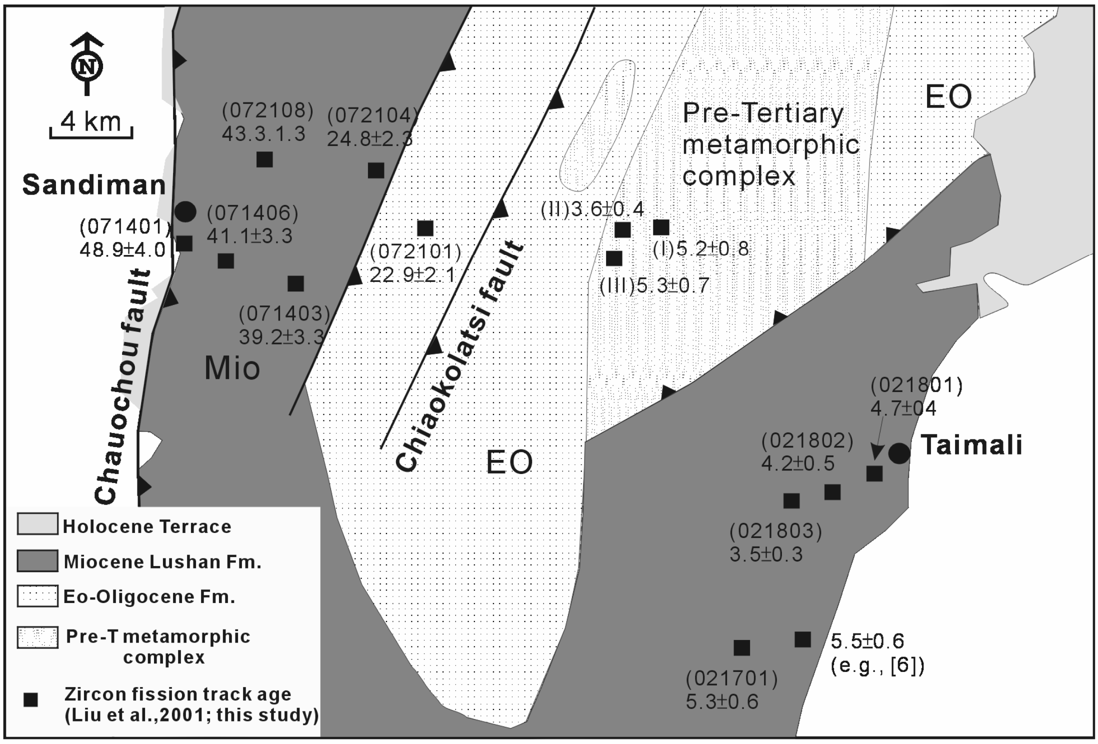

Figure 1 Study area and pooled ages of zircon fission-tracks in Ma. Location shows in Figure 1. West of the Chiaokolatsi fault all samples are partially annealed. East of the Chiaokolatsi fault, the ages range from 3.5 ~ 5.5 Ma.

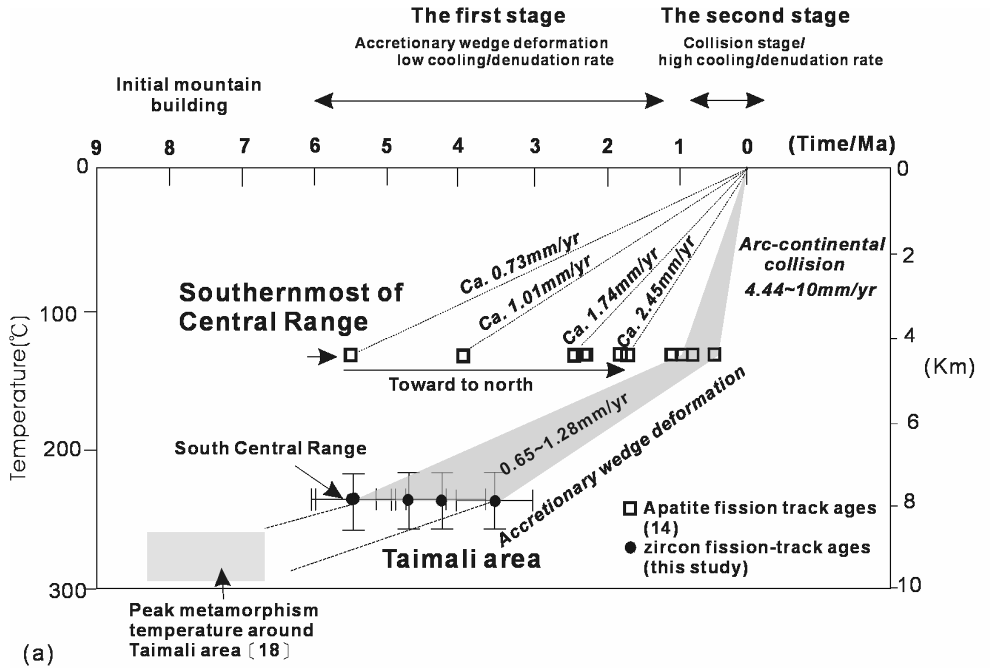

Figure 2 Cooling and denudation rates of the southern Central Range. The first stage mountain building results from the accretionary wedge deformation with a slow denudation rate. The second stage mountain building results from the arc-continental collision with a high denudation rate.