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Tectonophysics 274 (1997) 1–4

TECTONOPHYSICS

An introduction to active collision in Taiwan

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Keywords: Taiwan; arc–continent collision; Philippine Sea plate; mountain building; subduction

1. Introduction

This issue contains a collection of twelve papers on 'Active Collision in Taiwan' (ACT) presented at the 3rd Sino–French symposium in Taipei, Taiwan, 22–23 March 1995. Previous Sino–French symposia on earth sciences have been held in Taipei (1984) and Paris (1988). Proceedings have been published in special issues of *Tectonophysics* in 1986 (Angelier et al., 1986) and 1990 (Angelier, 1990). Unlike the previous Sino–French symposia, which emphasized the eastern Taiwan margin, the 45 (oral and poster) papers presented at the 3rd meeting were focused on Taiwan geodynamics. The conference took place just before two recent major marine geology and geophysics cruises, aimed at improving our knowledge of the geology of Taiwan and surrounding seas. Thus, results of the geophysical cruises, conducted aboard R/V *M. Ewing* (deep-seismic reflection and OBS) in September 1995 and R/V *L'Atalante* (swath-mapping and seismics) in June 1996, are not mentioned in this volume. A fourth Sino–French symposium will be organized in France in 1998 to present the main results from these oceanographic cruises, as well as the recent developments of onland geology.

For many authors, the Taiwan mountain belt is the result of an extremely recent arc–continent collision (e.g. Biq, 1972). The continent is represented by the shelf of mainland China (Eurasia plate) and the arc is the Luzon volcanic arc which results from the east-dipping subduction of the South China Sea (Eurasia plate) under the Philippine Sea plate (Fig. 1). Because of the obliquity of convergence between the Eurasia and the Philippine Sea plates, collision presently occurs south of Taiwan (stage 1 in Fig. 1), near the transition between oceanic and continental crusts within the subducting lithosphere of the Eurasia plate, and culminates on the island of Taiwan (stage 2 in Fig. 1) (Suppe, 1981). The highest peak, Yushan, in the Central Range, reaches 3952 m (Ho, 1986). The northern part of Taiwan is less active, except the Hualien area, but it was actively deforming in recent times as deduced by the simple model of southward propagation of collision through time (stage 3 in Fig. 1). In addition to the oblique collision, a geometrical complexity occurs near Hualien, which explains the high level of seismicity in this sector. The Philippine Sea plate, which carries the Luzon volcanic arc, is subducting under the Ryukyu arc. The opening of the Okinawa back-arc basin resumed since 1 or 2 m.y. B.P. possibly because compressive stress was released after collision (stage 4 in Fig. 1).

We have classified the papers in this special issue following the different stages illustrated in Fig. 1 from incipient collision in the south to extension after collision in the north. At the end, two papers present evolutionary models based on various approaches.

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PII S0040-1951(96)00294-6

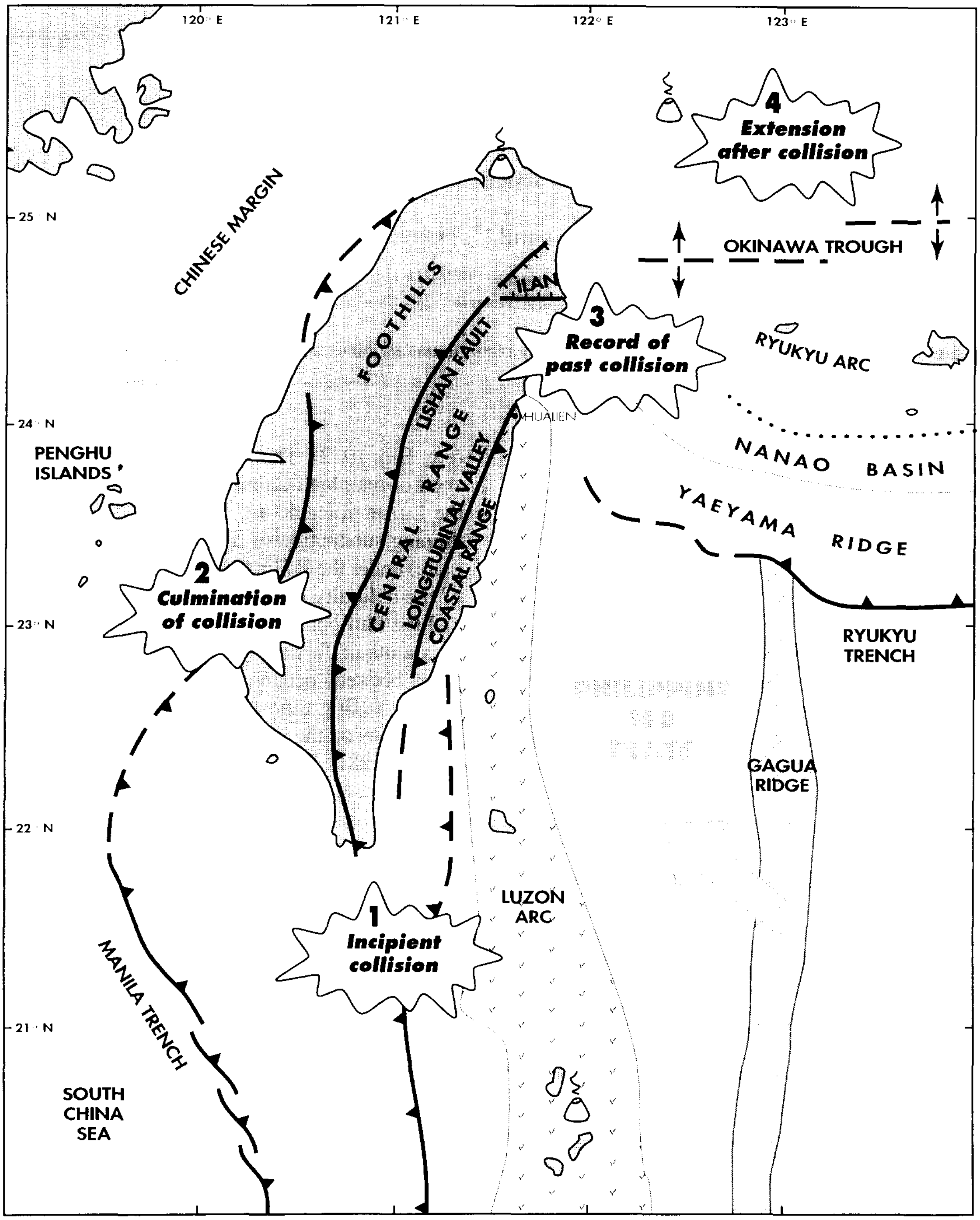

Fig. 1. Simplified structural map of Taiwan and surrounding areas on which the four main stages of arc–continent collision are indicated from south to north. The black arrow indicates plate convergence.

2. Incipient collision

In May and June of 1990, a marine geophysical survey was carried out by the US R/V *Moana Wave* in the area off southern Taiwan to investigate the Luzon subduction system and the submarine Taiwan incipient collision zone. SeaMARC II side-scan imagery, 6-channel seismic reflection data and other geophysical data were collected. Lundberg et al. (this issue) present some results of this cruise. They show that the Luzon accretionary wedge is backthrust over, thus closing, the fore-arc basin from south to north. Fuh et al. (this issue), based on the same geophysical data, propose a bookshelf rotation model to explain the observed geometrical relationships of the strike-slip fault system that cut the arc and fore-arc.

3. Culmination of collision

New geodetic data represent a major scientific advance of our understanding of the ongoing deformation of Taiwan, with important consequences on geodynamic models. Yu et al. (this issue) present the results of five-year geodetic measurements over the extremely dense Taiwan GPS network. Their map of the velocity field in the Taiwan area clearly shows that plate convergence is no longer accommodated onland in the northern part of the island, whereas most of the shortening occurs onland in the south. Detailed analysis of particular regions provides firm constraints in most of the papers of this issue. Three papers focus on the western foothills of Taiwan (Fig. 1) which are actively deforming. Quaternary transfer faulting is evidenced from a multisource approach (Deffontaines et al., this issue). Relationships between extension and compression are studied in the Pleistocene reefal limestones near Kaoshiung (Lacombe et al., this issue).

In most of the tectonic models, the Lishan Fault (Fig. 1) has played a major role during collision. A detailed analysis of this fault illustrates its kinematics and polyphase history (Lee et al., this issue). The most recent suture zone between the Luzon volcanic arc and the Eurasia plate is probably the Longitudinal Valley between the Coastal Range and the Central Range (Fig. 1). Angelier et al. (this issue) present repeated measurements of active deformation on faulted concrete structures along an active fault, which is considered as the present-day plate boundary between the Philippine Sea plate and Eurasia. This fault segment accounts for about 2 cm/yr of the total 7 cm/yr plate convergence. An interpretation of the active deformation of southern Taiwan is proposed by Hu et al. (this issue) based both on numerical simulation (finite-element and distinct-element methods) and GPS studies. They conclude that the velocity field and tectonic stress pattern in this area strongly depend on the presence of a topographic high on the subducting shelf acting as an indentor, and on major active regional discontinuities such as lithospheric thrusts and weakness zones.

4. Record of past collision

Marine seismic studies have allowed Lallemand et al. (this issue) to recognize two superposed sedimentary basins that were previously unknown offshore northeastern Taiwan. One of these basins has been intensively deformed possibly during the main collision phase and then subsided more than 3 km. The authors suggest that the episode of subsidence could be related to the failure of the Philippine Sea plate along a tear fault aligned with the Ryukyu fore-arc basins. Collision still occurs near Hualien, but the area located just north of Hualien undergoes subsidence and extension at present.

5. Evolutionary models for Taiwan

Wu et al. (this issue) test two hypotheses: the thin-skinned tectonics in opposition to the lithospheric collision, on the basis of seismological and geophysical data. They observe a strong participation of the crust and the upper mantle and thus favour the lithospheric collision between the Philippine Sea plate and the Eurasia plate. Sibuet and Hsu (this issue) present a provocative concept, based on marine gravity anomalies and geological data. They propose that the Ryukyu subduction zone and associated back-arc basin extended west of the present Manila Trench before the main collision with the Luzon arc. Consequently, they propose an arc–arc collision, one of the arcs being a 'palaeo-Ryukyu arc', instead of an arc–continent collision model. Finally, Chemenda et al. present a 'mechanically correct' evolutionary model for the Taiwan collision, based on physical modelling using scaled analogs for the two types of lithosphere.

6. Conclusion

A large volume of new data collected, onland (GPS...), offshore (seismics...) and 'inlab' (modelling...) are presented in this special issue. Various interpretations are proposed that will be tested in the light of the new geophysical and geological data recently acquired both offshore and onland. Taiwan is an excellent natural laboratory for studying the concepts of mountain building, because the processes are still active and can be observed at different stages from south to north and also because major cooperative projects have been accomplished or are scheduled for the near future.

Acknowledgements

We thank Prof. Char-Shine Liu, from Institute of Oceanography of the National Taiwan University, and Prof. Jacques Angelier, from Geotectonics Department of Pierre and Marie Curie University for their very efficient management of the Sino–French cooperative program in Earth Sciences. We also thank Drs H.-T. Chu, C.-Y. Huang, C.-Y. Lee, J.-C. Lee, T.-Q. Lee, C.-W. Lin, C.-Y. Lu, L. Teng, P. B. Yuan, Mrs C.-P. Chang, N.-T. Lin, W.-Y. Wu, M.-S. Yu and Ms H.-L. Jen for their efforts in organizing both the symposium in the Taipei International Convention Center and the post-conference field trip across the Hengchun Peninsula, the Coastal Range, the Central Range and the Hsuehshan Range. The Symposium was sponsored by the National Science Council (NSC) of Taiwan, the French Institute in Taipei (FIT), the Geological Society of China (GSC), the Institute of Oceanography, National Taiwan University (IONTU), and the Department of Geology, National Taiwan University (DGNTU). A volume of extended abstracts of the conference (Tsien, 1995), as well as a field trip guide (Huang and Yuan, 1995) have been published by the Geological Society of China. We also warmly acknowledge the fifty referees who evaluated the manuscripts.

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