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Eruption and emplacement of a laterally extensive, crystal-rich, and pumice-free ignimbrite (the Cretaceous Kusandong Tuff, Korea)

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ABSTRACT

The Cretaceous Kusandong Tuff, Korea, is a thin (1–5 m thick) but laterally extensive (~200 km) silicic ignimbrite emplaced in a fluviolacustrine basin adjacent to a continental volcanic arc. The tuff has been used as an excellent key bed because of its great lateral continuity and unique lithology, characterized by the virtual absence of juvenile clasts and an abundance of quartz and feldspar crystals (up to 55–73 vol.%). The tuff is mostly massive and ungraded and locally shows crude internal layering, basal inverse grading and near-top normal grading of crystals, either erosional or non-erosional lower surfaces, and flat-lying to imbricated grain fabrics. Fragile intraformational clasts of mudstone and tuff are also included. These features provide only ambiguous information on the properties of the responsible pyroclastic density currents: i.e. whether they were dense and laminar or dilute and turbulent. The overall lateral continuity and sheet-like geometry of the tuff suggests, however, that the transport system of the currents was highly expanded, dilute, and turbulent. A plug-flow or slab-flow model cannot explain the origin of crude internal layering, imbricated grain fabrics, and the high crystal content, which is most likely the result of vigorous sorting processes within a dilute and turbulent current. Features indicative of deposition from a dense and laminar transporting medium are locally present, suggesting that a dense and laminar depositional system could develop locally at the base of the dilute and turbulent transport system. The virtual absence of juvenile clasts in the tuff is interpreted to be due to rapid ascent, sudden decompression, and full fragmentation of silicic magma into fine glass shards and crystals. Scarcity of basement-derived accidental components together with the absence of pumiceous fallout deposits beneath the tuff is interpreted to be due to shallow-level fragmentation of magma followed by immediate generation of pyroclastic density currents from shallow-level blasts at the onset of eruption. The eruption occurred through multiple vent sites in a short period of time, producing a seemingly single but actually composite ignimbrite unit. Such an eruption was probably possible because of a regional tectonic event within the basin or in its vicinity. It is proposed that a composite ignimbrite with the characteristics of the Kusandong Tuff can be an exemplary product of syntectonic volcanism that can provide an insight into the interpretation of structural and stratigraphic evolution of a sedimentary basin.

1. Introduction

Ignimbrite is the deposit of a pumice-rich pyroclastic density current or 'pyroclastic flow' which flows rapidly from a volcano as a hot suspension of volcanic particles and gases, constituting the most destructive and lethal means of pyroclastic transport and volcanic hazards (Fisher and Schmincke, 1984; Cas and Wright, 1987; Valentine and Fisher, 2000; Wilson and Houghton, 2000; Branney and Kokelaar, 2002). Ignimbrite commonly has the geometry of an extensive sheet, extending as far as or more than 100 km from its source or sources (Wilson, 1985; Wilson and Walker, 1985; Suzuki-Kamata and Kamata, 1990; Fisher et al., 1993; Streck and Grunder, 1995). Such ignimbrite sheets therefore act as superb regional stratigraphic markers that can help unravel the structural evolution and depositional history of structurally complex sedimentary basins (de Silva and Francis, 1989; Fackler-Adams et al., 1997; Lebti et al., 2006; Jeong et al., 2008). They are therefore worthy of detailed investigation not only from a volcanological point of view but also from a sedimentological/stratigraphical perspective.

The Gyeongsang Basin is the largest Cretaceous sedimentary basin in Korea, which developed adjacent to a continental volcanic arc (Choi, 1986; Chough et al., 2000) (Fig. 1). The basin is filled by a c. 9 km-thick sequence of nonmarine deposits with abundant volcanogenic rocks (Chang, 1975, 1977). Probably the most prominent of these

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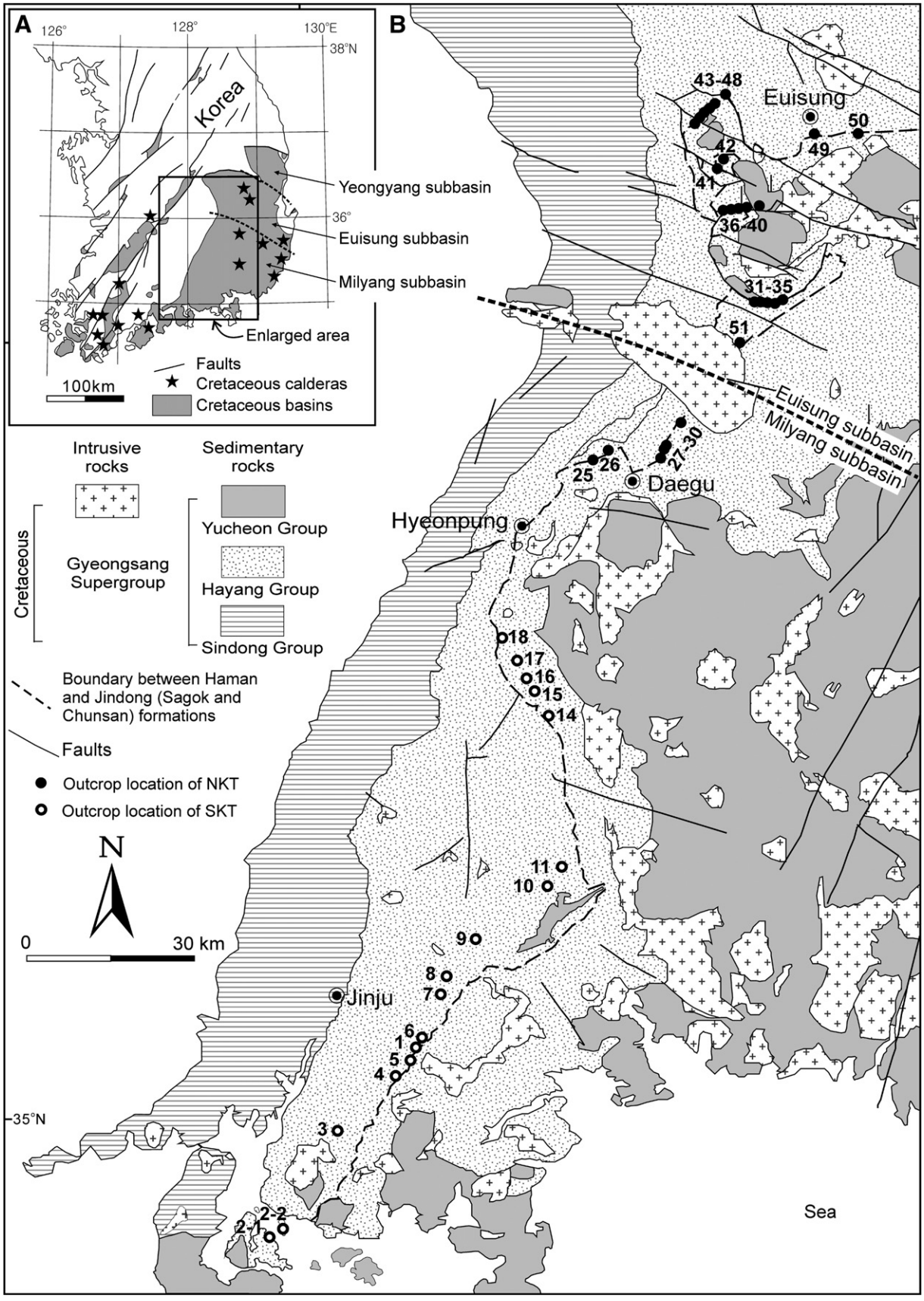

Fig. 1. (A) Distribution of Cretaceous sedimentary basins, calderas, and major fault systems in South Korea (compiled from Chang, 1977; Cha and Yun, 1988). (B) Simplified geological map of the western part of the Gyeongsang Basin (Chang, 1975, 1977, 1988) with outcrop localities of the Kusandong Tuff. The basinfill strata are generally undeformed and tilted gently (10–20°) toward the northeast or southeast.