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Paleomagnetic constraints on the paleogeography and oroclinal bending of the Devonian volcanic arc in Kazakhstan

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Abstract

A prominent feature of the central part of the Ural–Mongol orogenic belt is a series of concentric horse-shoe shaped volcanic arcs, with the youngest arc on the inside. This structure was long-suspected to be an orocline, but unequivocal evidence for this was lacking, mainly because paleomagnetic results of suitable age from this area remained sparse, but also because their interpretation was not straightforward due to a long history of deformations associated with the protracted late Paleozoic assembly of Asia.

Our paleomagnetic study of Middle Devonian basaltic and andesitic flows in southeastern Kazakhstan revealed two main components of magnetization. The primary nature of a high temperature magnetization (tilt corrected Dec = 286.5, Inc = 46.4, α_{95} = 7.8, k = 29.2, N = 13 sites) is supported by the presence of antipodal directions and a baked-contact test. We also isolated a post-folding overprint with an *in situ* mean direction Dec = 134.9, Inc = −43.0 (α_{95} = 4.9, k = 71.6, N = 13 sites). The age of this overprint can be estimated as Early Permian with a high degree of confidence. The declination of the overprint is seen to be deflected counter-clockwise by 100 ± 6° relative to the 290-Ma reference direction, indicating that the studied locality, similar to many other localities in the region, was affected by late-orogenic rotations. We use the overprint's deflection to correct the declination of the primary Devonian magnetization for these late-orogenic block-rotations.

Declinations from other Silurian and Devonian paleomagnetic results in the subduction-related Devonian volcanic arc of Kazakhstan have been corrected for such rotations wherever the latter are reasonably well documented. Using corrected declinations as passive markers we restored the trend of the volcanic belt to its Devonian configuration. Our analysis indicates that the presently curved belt was nearly straight and NW–SE trending. This ~1500 km long volcanic belt characterized the northeastern margin of a landmass in today's central Kazakhstan where subduction occurred towards the southwest. Oroclinal bending of this arc took place in the interval between the Middle Devonian and the Late Permian.

Keywords: Paleomagnetism; Kazakhstan; Oroclinal bending; Devonian; Paleogeography

1. Introduction

It is now widely recognized that Central Asia is a composite realm assembled during the Phanerozoic by accretion of various continental blocks, island arc

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fragments, and accretionary complexes (Fig. 1). The assembly mechanism is still disputed for the early Paleozoic, however. Regardless whether authors favored collision of microcontinents that were originally separated by oceanic basins and multiple island arcs (Mossakovsky et al., 1993; Didenko et al., 1994; Dobretsov et al., 1995; Filippova et al., 2001; Windley et al., 2007), or forearc accretion and oroclinal bending of a single, long-lived subduction system (Şengör and Natal'in, 1996), most scientists agree that by the middle Paleozoic several relatively small terranes had amalgamated into a single tectonic unit (often referred to as "Kazakhstania", but the definition of this concept may differ from author to author). Possibly from Early Silurian onwards (Degtyarev and Ryazantsev, 1993) and certainly from Late Silurian to Early Permian time, volcanic arc structures marked one of the margins of the amalgamated block (Bakhtiev, 1987; Zonenshain et al., 1990; Kurchavov, 1994; Skrinnik and Horst, 1995). In their present-day configuration, the Devonian and late Paleozoic volcanic belts are horse-shoe shaped (Fig. 2). The area internal to the strongly curved volcanic structures is dominated by rocks indicative of deeper marine environments, whereas the regions surrounding

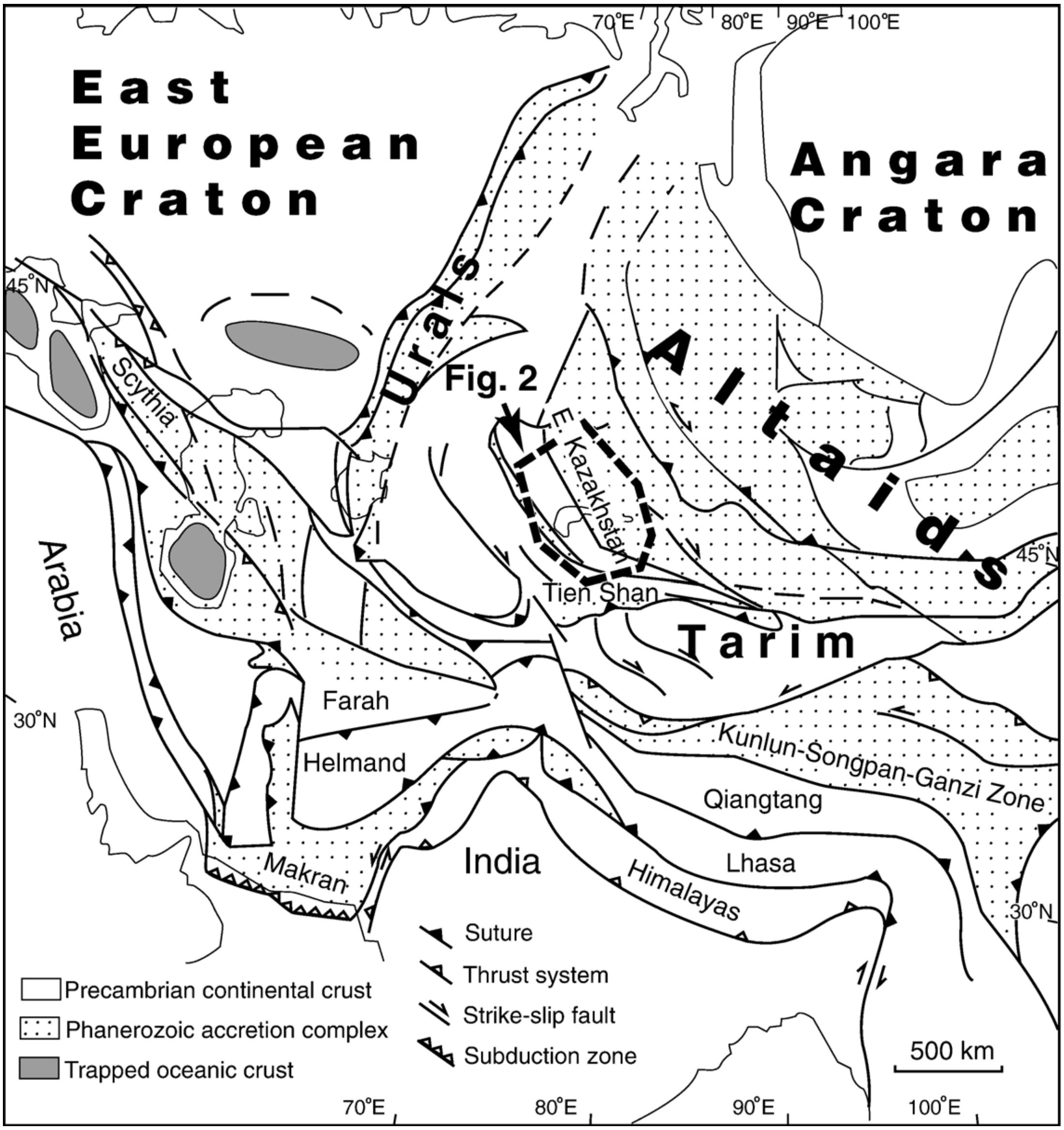

Fig. 1. Schematic map of central Asia, showing the location of the East Kazakhstan study area, wedged in between the Tarim, Baltica and Siberia cratons (modified after Allen et al., 2001).