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Tracing archives of intra-oceanic arcs and tracking periods of subduction erosion: evidence from greywacke sandstones of central and eastern Kazakhstan

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Proportions of juvenile and recycled crust in intra-continental orogenic belts formed in place of paleo-oceans as a key issue of tectonic and metallogenic paleo-reconstructions. Major sites of the growth of juvenile continental crust are intra-oceanic arcs at Pacific-type convergent margins. However, island-arc igneous complexes can disappear from the geological record because of tectonic erosion. Erosion of magmatic arc leaves either clastic rocks, typically greywacke sandstones, often parts of trench/fore-arc/back-arc turbidite associations.

For reconstructing ancient Pacific-type convergent margins, we must know which types of arcs existed that time: intra-oceanic or continental. Fossil Pacific-type orogenic belts typically exhibit very complicated relationships between different lithologies, often with few, if any, outcrops of arc igneous rocks. We reconstructed fossil intra-oceanic arcs in central and eastern Kazakhstan, which existed at Pacific-type convergent margins of the Paleo-Asian Ocean (PAO) in Paleozoic time. Our reconstructions are based on published and new U-Pb detrital zircon ages, petrographic, geochemical and isotope (Sm-Nd, Lu-Hf) data from greywacke sandstones hosted by accretionary complexes of central and eastern Kazakhstan in comparison with data from arc igneous rocks, in particular, with those occurring as fragments in serpentinite mélange.

Four orogenic belts of the western Central Asian Orogenic belt are under consideration: Itmurundy and Tekturmas in central Kazakhstan (early Paleozoic) and Zharma and Char in eastern Kazakhstan (middle-late Paleozoic). All orogenic belts formed at active margins of the PAO. Study of greywacke sandstones represent a valuable instrument for reconstructing survived and disappeared magmatic arcs taking into account episodes of subduction erosion. In addition, the role of serpentinite is also very important for the reconstruction of episodes of tectonic erosion. We argue that (1) all sandstones hosted by accretionary complexes are greywackes deposited close to their igneous sources and buried rapidly; (2) their provenances are dominated by mafic to andesitic igneous rocks; (3) the parental melts of their igneous protoliths were derived from juvenile mantle sources; (4) the igneous protoliths are typically emplaced in intra-oceanic arc settings; (5) the sandstones get deposited in fore-arc/trench basins or, to a lesser degree, in back-arc basins.

The data from sandstones and serpentinite mélange allowed us to reconstruct middle-late Cambrian and Ordovician arcs in the Itmurundy and Tekturmas belts and late Devonian and Carboniferous arcs in the Zharma and Char belts. The obtained results clearly show signatures of subduction erosion in both early and late Paleozoic times. Evidence for this comes from (1) disappearance of certain peaks of U-Pb ages in younger sandstones compared to older ones (Tekturmas, Char, Zharma); (2) scarce/small outcrops of arc igneous complexes (Itmurundy, Char); (3) presence of pieces of arc rocks in serpentinite mélange (Itmurundy, Tekturmas, Char); (4) magmatic lulls. The middle-late Cambrian arcs (Itmurundy, Tekturmas) were fully destroyed by subduction erosion. The Ordovician arc survived better, but that of the Itmurundy belt was stronger destroyed compared with the coeval arc of the Tekturmas belt. The late Devonian arc of the Zharma belt better survived than that of the Char belt. Both, the early and late Paleozoic active margins of the PAO were characterized by alternating periods of accretionary growth and subduction erosion.

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