Tectonic evolution of the Pilbara Craton, Western Australia

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The North Pole area (3.5 Ga) in the Pilbara Craton, Western Australia is one of the best regions in the Archean cratons to investigate accretion process at subduction zone, because this area had been subjected only to very low-grade metamorphism. A 1/5,000 scale mapping was performed in the North Pole area. The mapped area is divided into seven units bounded by layer-parallel thrusts: Units-I, -II, -III, -IV and -V in ascending order. These units are divided into MORB-type (Unit-I and -II) and OIB-type (Unit-III, -IV and -V) units by lithology and mode of occurrence of bedded cherts. The Unit-I and -II, the best exposed, are composed of 19 and 22 tectonic slices (horses) with similar lithostratigraphy, bounded by layer-parallel thrusts. Duplex structures are developed in these units. About 150~300 % minimum shortening by duplexing are recognized in this area. The evidence of duplex structure and oceanic plate stratigraphy indicates that the North Pole area is an Archean accretionary complex.

The reconstructed lithostratigraphy of each horse in MORB-type units reveals a simple pattern, from basaltic and pillowed greenstone, through bedded chert layer to mafic sedimentary rocks on the top, in ascending order in the same unit. This lithostratigraphy is quite similar to Phanerozoic oceanic plate stratigraphy, except for the mafic sedimentary rocks. The abundant mafic component in top-sitting sedimentary rock suggests that the accretionary complex was formed in the intra-oceanic environment comparable to the present-day western Pacific Ocean. The sense of shear with horizontal shortening is top-to-the-east which indicates westward subduction. The five-fold pile nappe structure of granite-greenstone complex in the North Pole region indicates that the structural top is the oldest accreted unit, whereas the bottom is the youngest. This is opposite against the rift basin model proposed by previous workers.

To test this model, geochronological study was also achieved. The separated zircons from the tuffaceous chert beds in the Unit-III indicate the age of 3463 and 3434 Ma. The zircon from rhyolite in the Unit-IV, which is structurally near-top unit, shows the oldest age of 3660 Ma among the units from Unit-I to Unit-IV. The zircon from the granite indicates the youngest age of 3393 Ma. The obtained zircon U-Pb ages of the Units-III and -IV and the granite body indicate that the greenstone/chert succession in the North Pole area cannot be interpreted by the rift basin model.

Yet, Ohta et al. (1996) analyzed the eastward subduction to form the Cleaverville accretionary complex from the western end of the Pilbara Craton. The age of the formation was ca. 3050 Ma. This does not support the simple eastward or westward growth of accretionary orogen in the Pilbara Craton. The age of TTG intrusion is not also simple. About 30 TTG plutons are present in the Pilbara Craton, and their formation has been once regarded to be westward younging with time (Krapez, 1993). However, the age distribution is not simple, supporting this traditional interpretation.

The abundance of mafic sedimentary rock in the reconstructed oceanic plate stratigraphy and different directions of subduction at eastern and western side of the Pilbara Craton suggest that the craton was formed in the intra-oceanic environment comparable to the present-day western Pacific Ocean by collisions of intra-oceanic arcs.