# Resolving orogenic events in construction of the Lützow-Holm Complex, east Antarctica

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The intra-continental Lützow-Holm Complex (LHC) was metamorphosed at amphibolite-facies (eastern section along the Prince Olav Coast, POC) to UHT granulite-facies (western section in southern Lutzow-Holm Bay, LHB), during the final Cambrian assembly of East and West Gondwana. Although the retrograde (post-construction) stages of orogenesis, between 530 and 430Ma, are beginning to be well characterised, there is evidence from multiple aspects that the orogenic construction of the complex was either prolonged or multistage in nature, and that the timing of peak metamorphism was in places decoupled from the timing of continent-continent collision. Strands of evidence include the preservation of moderate-high pressure (>10kbar) relict assemblages in high-T, moderate-P granulites; decompression reaction textures both before and after peak metamorphism; the lack of clear tectonic boundaries between lithological units that could represent sutures between exotic crustal blocks; the obscuration of syn- or intra-tectonic magmatic relationships by intense ductile reworking, and the preservation of metamorphic zircon growth at multiple stages during the Ediacaran and Cambrian Periods, especially in the southwestern, higher-grade section of the LHC.

During the summer season of JARE52, a widespread survey of localities across LHB and along the POC was conducted by the authors in order to resolve stages of orogenic activity, building on the extensive work of numerous scientists throughout the history of JARE. A sharp transition of the dominant orientation of major tectonic features and lithological types was confirmed along the Telen Glacier; charnockite-dominated lithologies to the north were wrapped into westward-verging recumbent folds and shear zones, whereas south of the glacier tectonic intercalations of supercrustal lithogies and charnockitic basement were reworked by steep to vertical E-W lateral shearing, with a dextral sense in most localities. The absence of discrete structural features that might identify a tectonic suture along the Telen Glacier, suggests that this tranistion is instead the reworking of a pre-existing orogenic boundary, and that the steep ductile fabric in the south represents pervasive tectonic reworking that has widely obliterated pre-orogenic lithological relationships. Despite this, domains of crustal provenance can be identified through a combination of distinctive lithological assemblages, protolith geochronlogy from zircon U-Pb and Nd model crustal ages, and geomagnetic variation. The following lithological groups are tentatively proposed (ages are of non-metamorphic protoliths, localities of outcrop are in parentheses):

- (i) **Rundvåg orthogneiss:** ca. 2.5Ga felsic to intermediate orthogneiss (between Rundvågshetta and Botnnuten, and possibly as far north as Sudare Iwa; well represented in southern LHB moraines)
- (ii) **Skallen orthogneiss:** ca. 1.85Ga felsic to intermediate orthogneiss (Skallen and Skallevikshalsen, possibly Berrodden and Telen)
- (iii) **Skallevik supercrustal sequence:** Mesoproterozoic and/or Neoproterozoic metasediments, including metaquartzite and metapelite with detrital zircon derived from group (i), and scapolite-bearing calc-silicates and dolomitic marbles. Likely to comprise unrelated sedimentary packages (Telen to Botnnuten to Austhovde; high proportion of marbles and calc-silicates in morianes at Rundvågshetta and Innhovde indicates widespread extent under the icesheet)
- (iv) **Ongul orthogneisses:** ca. 1.05Ga felsic to mafic orthogneisses, varying from charnockite to garnet-bearing porphyritic orthogneiss to pyroxenite. Probably comprises contemporaneous but unrelated magmatic suites (Kjuka to Ongul Island, possibly Innhovde and Karamete Point, possibly along the POC)
- (v) **Oku Iwa orthogneiss:** ca. 630Ma felsic to intermediate orthogneiss (East Ongul Island, Oku Iwa, possibly along the POC), intruded into (iv)
- (vi) **Syowa paragneiss:** Ediacaran metapelite, containing detrital zircon derived from (iv), (v), and unknown continental sources, but not (i) or (ii). (East Ongul Island, Langhovde, Skarvsnes, POC)
- (vii) **Hinode metamorphic suite:** Ca. 1020Ma magmatic arc suite, plus post-1020Ma metasediments, metamorphosed ca. 960Ma. Detrital zircon in metapelite share continentally derived ages with (vi)

Other pre-orogenic magmatic suites of unknown age are likely to be present, and can be recognised especially in localities along the POC, where the intensity of deformation and metamorphism is not as great as in LHB. In addition to these pre-orogenic suites, granitic and mafic intrusions could be identifed in southern LHB that were emplaced between episodes of ductile deformation, especially in relatively low-strain domains between steep E-W transverse ductile shear zones. These low strain domains with inter-tectonic intrusions are found in LHB at Innhovde, Austhovde, Vesleknausen, south Rundvågshetta, Berrodden, Telen and Kjuka. Multiple stages of magmatism and deformation can also be resolved at all localities visited on the POC during JARE 52, between Tama Point and Niban Iwa. Dating of these intra/syn- intrusions is required to resolve the timing of orogenic events in the LHC.

A model of orogenesis is tentatively proposed that involves an initial stage of continent-continent collision, possibly with the entrainment of small, diverse crustal blocks, from about 600Ma, an age closer to the peak of orogenesis in the adjacent Sør Rondane Mountains. Peak metamorphism and ductile strain is not co-incident with initial collision, but occurs in crustal blocks in a very large, long-lived orogen, where upper to middle crustal blocks have become horizontally decoupled from the lower lithosphere, obscuring original plate boundaries. A similar model has been proposed for the Grenvillean orogen of North America. It provides a concept that can be tested by the identification of prolonged or polystage orogenesis in other parts of the “Pan-African” orogen that assembled East and West Gondwana. In other regions with high-grade Cambrian metamorphism, in Mozambique, Madagascar, India and Sri Lanka, evidence of additional Ediacaran collisional orogenesis is beginning to emerge.