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Carbonate Assimilation in the Alkaline Hortavaer Igneous Complex, Norway

C. G. Barnes

Y. Li

M. Barnes

L. McCullock

Carol Frost
University of Wyoming, frost@uwyo.edu

See next page for additional authors

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Authors
C. G. Barnes, Y. Li, M. Barnes, L. McCullock, Carol Frost, T. Prestvik, and C. Allen

Felsic volcanism in the eastern Yilgarn Craton: Evolution of a Late Archean convergent margin

M.E. Barley, S.J. Brown, B. Krapez

School of Earth and Geographical Sciences, University of Western Australia, Crawley, WA 6009, Australia (mbarley@segs.uwa.edu.au)

Felsic volcanic and volcanogenic sedimentary rocks form significant components of Late Archean greenstone belts and comprise ~20% of outcropping greenstones in the eastern Yilgarn Craton. On the basis of trace element geochemistry, volcano-sedimentary facies, post 2.72 Ga felsic volcanic rocks in the Eastern Yilgarn have been divided into three associations.

(1) Calc-alkaline andestite dominated complexes and associated sedimentary rocks characterise the Kurnalpi Terrane, and range in age between 2704 and 2716 Ma. Volcanic facies, and the geochemistry of intermediate lavas are similar to those in modern intra-arc settings, and imply a similar tectonic environment. The relatively large range in εNd_T values for Kurnalpi Terrane andesites indicates contributions from either subduction-modified mantle and/or older arc basement. High MgO, Ni, and Cr contents of basaltic andesites and andesites are consistent with derivation of parent magmas from a mantle source.
(2) Bimodal and intermediate to felsic sub-alkaline volcanic successions, including the high field strength element (HFSE) enriched Melita complex, define a younger age range (2692–2676 Ma), within the Gindalbie domain. This association is interpreted to represent a late rifting phase of the Kurnalpi Terrane arc. Both mafic and felsic lavas have relatively high εNd_T values, and rhyolites high zircon saturation temperatures (>800°), with no evidence of zircon inheritance, indicating that parent magmas were derived from subduction-modified mantle with minimal involvement of older crust, with rhyolites produced by ACF processes or melting of older arc crust.
(3) A high-Na dacite dominated (TTD) association is characteristic of the Kalgoorlie Terrane. This association represents episodic volcanism between ~2710 and 2660 Ma. Andesites and dacites have a wide range of εNd_T values, dacites have low zircon saturation temperatures (750° to 800°), and both andesites and dacites contain inherited zircons. TTD suite volcanic rocks in the Kalgoorlie Terrane are most likely derived by hydrous melting of mafic-intermediate rocks (in the garnet stability field).

The composition, distribution, and age ranges defined by the post-2720 Ma associations are consistent with the evolution and accretion of several arc-related terranes within a convergent continental margin environment over a ~50 Myr period. Formation of continental crust in the Eastern Yilgarn during the Late Archaean involved both recycling of older crustal material as well as addition of new mantle-derived magmas.

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Carbonate assimilation in the alkaline Hortavaer igneous complex, Norway

C.G. Barnes[1], Y. Li[1], M. Barnes[1], L. McCullock[1], C. Frost[2], T. Prestvik[3], C. Allen[4]

[1]Geosciences, TTU, Lubbock, TX, USA (cal.barnes@ttu.edu)
[2]Geol. & Geophys., U. Wyoming, Laramie, WY, USA (frost@uwyo.edu)
[3]Geology, NTNU, Trondheim, Norway (tore.prestvik@geo.ntnu.no)
[4]RSES, ANU, Canberra, Australia (Charlotte.Allen@anu.edu.au)

The Hortavær intrusive complex provides an excellent natural laboratory for detailed study of effects of, and processes controlling carbonate assimilation in an orogenic setting. The intrusion was emplaced into marble and gneiss at ~475 Ma, during Caledonian metamorphism, as numerous subhorizontal sheets, of ne-normative gabbro and diorite to (ne-bearing) monzodiorite, to monzonite and syenite. Carbonate assimilation is apparent because carbon in primary calcite has a sedimentary origin (Barnes et al., 2005). Experiments (Iacono Marziano and Gaillard, in review) show that extensive carbonate assimilation is possible in H_2O-rich mafic magma, especially when evolved fluids can escape. This interaction produced augite at the expense of olivine, K_2O enrichment, and depletion of elements compatible in cpx. Syenite was produced along margins of mafic sheets and loading squeezed syenitic magma laterally away from the assimilation zone. Central interlayered mafic rocks, syenite, and endoskarns were surrounded by an outer zone of syenite sheets. Local homogenization of hybrid magmas was promoted by evolution of mixed H_2O–CO_2 fluid; however, because assimilation was local, syenites vary in silica saturation, K/Na, and trace element contents; a homogeneous syenitic magma never formed. Carbonate assimilation stabilized titanite and locally grossular-andradite garnet and scapolite. Titanite + cpx ± garnet sequestered Zr; zircon is absent in most samples. In cpx, Zr and Hf increase from low ppm levels to 400 ppm and 12 ppm, respectively, with differentiation. Cpx REE patterns vary from "typical" augite patterns in olivine gabbro to light and heavy REE-enriched patterns with negative Eu anomaly and a trough centered on Ho. Less pronounced patterns occur in amphibole. Garnet shows maximum normalized REE at Sm, with flat normalized HREE (~100×chondrites) and titanite REE patterns steepen with differentiation. Compositional variations in cpx may result from equilibrium with garnet + titanite ± apatite or from growth in equilibrium with H_2O–CO_2 fluid, but we find no theoretical reason why Ho should be preferentially depleted by a fluid phase.

References

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