Economic Geology, v. 100, pp. 349–374

Late Archean Lake Harris Komatiite, Central Gawler Craton, South Australia: Geologic Setting and Geochemistry

DEAN M. HOATSON,[†] SHEN-SU SUN,[*]

Geoscience Australia, G.P.O. Box 378, Canberra, ACT 2601, Australia

MORRIS B. DUGGAN,

519 Mulquinneys Road, Braunstone, NSW 2460, Australia

MARC B. DAVIES, SUE J. DALY,

Minerals and Energy Resources, Department of Primary Industries and Resources, South Australia, G.P.O. Box 1671, Adelaide, SA 5001, Australia

AND ALAN C. PURVIS

Pontifex and Associates Pty. Ltd., P.O. Box 91, Kent Town, Adelaide, SA 5071, Australia

[*]*In memoriam:* This paper is dedicated to the life and scientific contributions of our friend, colleague, and mentor, Dr. Shen-Su Sun (Oct. 27, 1943–Feb. 25, 2005)—a world-respected geochemist who continually asked the question, "Why is this so?"

"Shen-Su was a great guy—the epitome of the committed scientist who modestly insisted on leading from behind and doing a helluva better job of moving science forward than those 'leading out front.'"

Wally Johnson, February 25, 2005

Abstract

The Lake Harris Komatiite in the central Gawler craton of South Australia is the first documented komatiite outside the West Australian craton and the easternmost occurrence of such primitive ultramafic rocks in Australia. A U-Pb zircon age of ca. 2520 Ga for the komatiitic sequence indicates a previously unknown period of mantle-plume activity in the Late Archean. An integrated program of airborne magnetic surveys, gravity surveys, and core drilling was successful in defining the distribution and volcanic architecture of the komatiitic flows and associated greenstones through an extensive thin cover of Cenozoic alluvial sediments. Surface exposure of the komatiitic rocks is restricted to one small outcrop near Lake Harris. The greenstones form a series of subparallel east-northeast–trending sinuous magnetic highs flanked by large ovoid to elongate magnetic highs and lows that correlate with Archean-Proterozoic granitic bodies associated with province-wide shear systems, similar to the Archean greenstone terranes in the Yilgarn craton of Western Australia.

The steeply dipping greenstone sequence was metamorphosed to middle amphibolite facies during the ca. 2440 Ma Sleafordian orogeny and sheared during the ca. 1700 Ma Kimban and ca. 1540 Ma Kararan orogenies. The greenstones consist of komatiite cumulates (43–32% MgO, anhydrous), high to low Mg komatiite (32–18% MgO), komatiitic and tholeiitic basalt (<18% MgO), pyroxenite cumulates, felsic volcanic rocks, minor metasedimentary rocks, pyroclastic rocks, and rare banded iron formation. They extend over 300 km in three subparallel belts that appear to be isoclinally folded around east-northeast axes and tectonically dismembered to the south by the Yerda shear zone. Komatiitic rocks have been confirmed by drilling in all three belts, but the absence of outcrop and structural complexities prevent detailed stratigraphic correlations within and between the belts.

The komatiitic rocks display a range of quenched and cumulus textures defined by the different habits of olivine and its alteration products. Trace sulfides (pyrrhotite, chalcopyrite, pentlandite, pyrite, marcasite, polydymite violarite, heazelwoodite, millerite) form very small (0.01–0.2 mm) single-phase disseminated grains and coarser disaggregated grains. Their distribution largely reflects metamorphic and serpentinization processes, with high Ni/S ratios and probable sulfur loss from the more magnesian parts of the flows. Rare composite pyrrhotite-pentlandite-chalcopyrite blebs (0.1–0.5 mm) characterize some low Mg flows. Locally, there is supergene pyrite-marcasite and native copper-bornite-chalcocite(?) assemblage infilling of late low-temperature serpentine-chlorite veinlets.

Thick ponded lava lake and distal composite sheet flow facies have been identified from different parts of the komatiitic sequences. Systematic whole-rock and mineral chemical trends indicate that despite the effects of recrystallization and reequilibration during amphibolite-facies metamorphism, the original magmatic geochemical profiles are largely preserved. The whole-rock data for the Lake Harris Komatiite does not show any obvious Ni depletion during fractionation but indicate a strong olivine control in dominantly sulfur undersaturated environments. Low sulfur (100–600 ppm S) and high Pd + Pt (5–30 ppb) contents, and Ti/Pd ratios of 2

[†] Corresponding author: e-mail, Dean.Hoatson@ga.gov.au

0361-0128/01/3500/349-26 $6.00

to 4×10^5 for the komatiitic rocks are similar to sulfur-undersaturated Archean komatiites hosting Ni-Cu-PGE deposits, i.e., there is little evidence for sulfur saturation in the sampled komatiites. Identification of a pre-2.5 Ga source of sulfur in the substrate would be a positive indicator of potential sulfur saturation of the lavas elsewhere in the greenstone belt and a possible target for mineralization.

The Lake Harris Komatiite has chemical (parent magma composition of 29% MgO, Al_2O_3/TiO_2 = 16, depleted light (L)REE and initial Nd isotope (ε_{Nd} = 2.8–3.0 at 2520 Ma) characteristics similar to typical Al-depleted Archean komatiites, and there is no clear evidence of chemical modification by processes associated with contemporary subduction. Coherent patterns of trace elements (Th, Nb, REE, Ti, Y, Zr, and P) and typical initial ε_{Nd} signatures indicate a Late Archean komatiitic system involving a depleted mantle source and no obvious crustal contamination. This system probably exploited a lithosphere that was stretched and thinned by extension and/or thermal erosion in an intraplate environment. Dynamic tectonic environments involving mantle-plume activity, long-lived active plate margins, and widespread arc volcanism during the Late Archean are now favored for the evolution of the western Gawler craton.