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2002

Natural Resources Canada
Ressources naturelles Canada

Canada

ISSN No. 1701-4387

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Publication approved by Continental Geoscience Division

SHRIMP U-Pb detrital zircon geochronology of enigmatic Neoarchean–Paleoproterozoic sedimentary rocks of the central western Churchill Province, Nunavut[1]

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Rainbird, R.H., Davis, W.J., Aspler, L.B., Chiarenzelli, J.R., and Ryan, J.J., 2002: SHRIMP U-Pb detrital zircon geochronology of enigmatic Neoarchean–Paleoproterozoic sedimentary rocks of the central western Churchill Province, Nunavut; Radiogenic Age and Isotopic Studies: Report 15; Geological Survey of Canada, Current Research 2002-F5, 8 p.

Abstract: The dominant U-Pb age of detrital zircons in three stratigraphically enigmatic sandstone units from the central part of the western Churchill Province ranges from 2730–2660 Ma, demonstrating mainly local provenance from underlying volcanoplutonic belts and that the units are younger than ca. 2.66 Ga. These ages are inconclusive for resolving the late Neoarchean versus early Paleoproterozoic depositional age of the sandstone units. A specimen from the Montgomery Group represents either a molasse developed late in the history of the underlying Neoarchean Henik–Kaminak–Tavani greenstone belt or an early Paleoproterozoic precursor to the Hurwitz Group. Younger grains in a specimen from the Spi Group support the interpretation that it represents a ca. 2450 Ma rift deposit, coeval with the Kaminak mafic magmatic event. A prominent ca. 2680 Ma detrital zircon mode in a specimen of quartzite from the Happy lake area and its aluminous composition are consistent with it being part of the lower Hurwitz Group.

Résumé : Les âges dominants de 2 730 à 2 660 Ma que révèle la datation U-Pb de zircons détritiques de trois grès à position stratigraphique indéterminée, dans le centre de la Province de Churchill occidentale, nous indiquent que les matériaux détritiques de ces unités de grès proviennent surtout de sources locales associées aux ceintures de roches volcano-plutoniques du socle sous-jacent et que ces grès datent de moins de 2,66 Ga environ. Les résultats de ces datations ne permettent pas de lever l'ambiguité quant au moment du dépôt des grès, qui se situe soit au Néoarchéen tardif ou bien au Paléoprotérozoïque précoce. Un échantillon du Groupe de Montgomery pourrait représenter soit une molasse formée tardivement dans l'évolution de la ceinture de roches vertes de Henik-Kaminak-Tavani du Néoarchéen du socle sous-jacent, soit un précurseur du Paléoprotérozoïque précoce du Groupe de Hurwitz. Des cristaux détritiques plus récents dans un échantillon du Groupe de Spi appuient l'interprétation voulant que ce grès soit un dépôt de rift d'environ 2 450 Ma, contemporain de l'épisode de magmatisme mafique de Kaminak. Les âges de zircons détritiques dans un échantillon de quartzite de la région du lac Happy, qui révèlent un mode bien marqué à environ 2 680 Ma, et la composition alumineuse de cette roche appuient l'hypothèse d'une appartenance à la partie inférieure du Groupe de Hurwitz.

[1] Contribution to the Western Churchill NATMAP Project

INTRODUCTION

Late Neoarchean and Paleoproterozoic sedimentary rocks are exposed in northwest-trending supracrustal belts representing about 30% of the surface area of the western Churchill Province (Fig. 1). These rocks provide an important record of regional tectonic events in the interval between major Archean crust formation at ca. 2.7–2.6 Ga and assembly of Laurentia at 2.0–1.8 Ga.

A persistent question in the western Churchill Province is the age of regionally restricted coarse siliciclastic units: the Spi Group (Beavon, 1976; Patterson 1991), the Montgomery Group (Aspler and Chiarenzelli, 1996), and a poorly understood unit of metasedimentary rocks from an area north of Quartzite Lake (Fig. 1). These rocks are considered to be of intermediate age between the lower Hurwitz Group, bracketed between 2.45 and 2.11 Ga (Aspler et al., 2001), and older synvolcanic sedimentary rocks of the Archean Kaminak–Henik Group (ca. 2.7 Ga; Mortenson and Thorpe, 1987). This sensitive high-resolution ion microprobe (SHRIMP) U-Pb study was undertaken because detrital zircon geochronology has proven to be an important tool for discriminating apparently similar rocks of differing age and tectonic setting. An improving regional geochronological dataset should 1) provide a better understanding of the regional stratigraphic assignment of these units; 2) give an indication of the relative contributions of local, regional, and/or exotic sedimentary sources; and 3) help in defining the tectonic significance of the basins in which they were deposited.

SAMPLE DESCRIPTION AND GEOLOGICAL SETTING

Three samples were selected for study, one each from the Montgomery Group (z5947), the Spi Group (z5203), and the unit of metasedimentary rocks from the Happy lake area, north of Quartzite Lake (z5202).

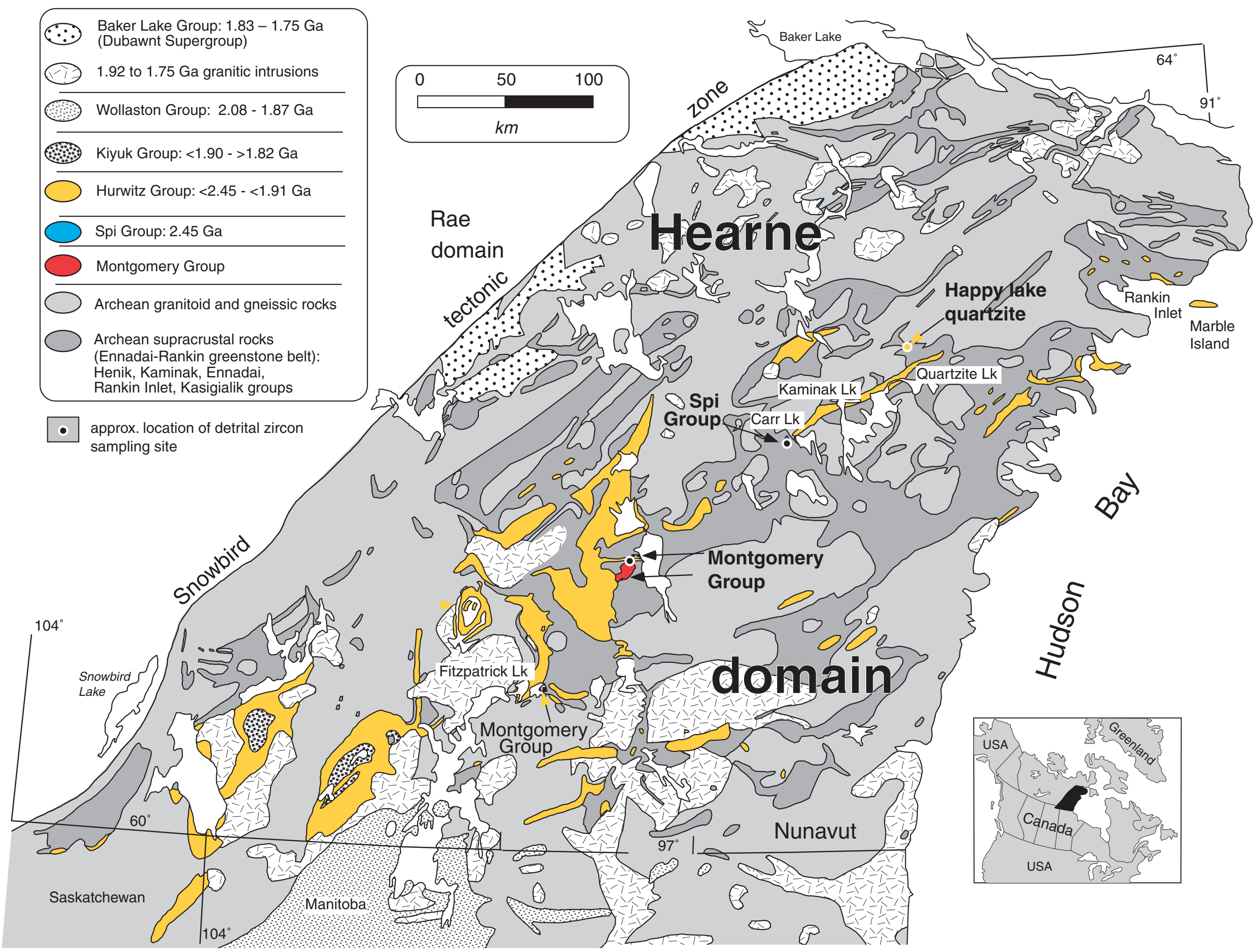


Figure 1. Simplified geology of the Hearne domain, showing location of samples collected for this study.

Montgomery Group sandstone

Exposed in the Montgomery Lake (Aspler et al., 1992; Aspler and Chiarenzelli, 1996) and Fitzpatrick Lake (Aspler et al., 2000) areas (Fig. 1), the Montgomery Group is separated from both the underlying Henik Group and the overlying Hurwitz Group strata by angular unconformities. In the type area at Montgomery Lake, the Montgomery Group drapes a low-relief paleotopography cut into previously tilted Henik Group strata, and consists of locally derived basal breccia (talus deposits surrounding paleohills), discontinuous lenses of polymictic conglomerate (basal fluvial channel-fill deposits), lithic arenite, and lithic wacke (predominant facies, fluvial deposits), and lenses of interbedded litharenite and siltstone (lacustrine facies). The analyzed sample is an arkose collected from immediately beneath the Montgomery Group–Hurwitz Group unconformity, north of Montgomery Lake (Fig. 1). At this site, steeply dipping Montgomery Group sandstone displaying a bedding-parallel fabric is overlain by gently dipping Hurwitz Group strata. The basal Hurwitz talus breccia contains blocks (with a randomly oriented internal fabric) derived from the immediately subjacent Montgomery Group (*see* Fig. 3 in Aspler and Chiarenzelli, 1996). The Montgomery Group sample is a fine-grained, well-sorted arkose with quartz and patchy carbonate cement. Recrystallization of quartz obscures the original grain boundaries and sericitic alteration of feldspars is ubiquitous.

Spi Group sandstone

Near the southwestern end of Kaminak Lake, the Spi Group is preserved in a narrow, north-northeast-trending belt, less than 1 km wide by up to 10 km long (Fig. 1). It includes coarsely plagioclase-phyric basalt flows of the Spi Lake Formation, and overlying conglomerate and arenite of the Old Boot Formation, collectively interpreted as a rift sequence unconformably overlying the Kaminak Group (Beavon, 1976; Patterson, 1991). Beavon (1976) noted the resemblance of the plagioclase-phyric basalt to the Kaminak dykes (2.45 Ga; Heaman, 1994) and suggested that the Spi Lake Formation was likely an extrusive equivalent to the Kaminak dykes, a correlation supported by recent geochemical results (Sandeman et al., 2000). Miller and Tella (1995) considered that basal flows were part of the Kaminak Group, but locally the Spi Group disconformably overlies volcanic rocks of the Kaminak Group. The basal conglomerate of the Old Boot Formation contains clasts of underlying tonalite and mafic volcanic rocks, some of which were cleaved prior to incorporation. Lithic arenite interbeds within the conglomerate contain heavy mineral laminae, which were sampled for detrital zircon analysis. The specimen from the Spi Group is a coarse, lithic arenite containing abundant comminuted tonalitic detritus, presumably derived from the nearby Carr Lake pluton.

Happy lake quartzite

The quartzite specimen collected for detrital zircon analysis comes from a succession of metasedimentary rocks exposed near Happy lake (informal name, not to be confused with Happotiyik Lake, which is further north) along the northern edge of the Kaminak segment, approximately 15 km north of Quartzite Lake (Fig. 1). The rocks are exposed over an area of about 40 km^2 and include psammite, psammitic phyllite, and 1–3 m thick interlayers of aluminosilicate-bearing quartzite, metamorphosed to lower amphibolite grade at ca. 1.83 Ga (Berman et al., 2002). Southward, the area is underlain by an increasing proportion of garnet-hornblende amphibolite. The Happy lake metasedimentary rocks are intensely transposed, exhibiting one main strong schistosity, parallel to compositional layering (Hanmer et al., 1998). The composition of the Happy lake metasedimentary rocks differs strikingly from the ca. 2.7 Ga Kaminak Group, which is dominated by immature volcaniclastic rocks, and from the coarse, relatively immature rocks of the Montgomery and Spi groups (discussed above). Stratigraphic position relative to the Kaminak Group and the Hurwitz Group is uncertain. The specimen from the Happy lake area is a medium- to coarse-grained, quartz-muscovite-kyanite psammite with a well developed schistosity. Muscovite (15%) occurs throughout, but is also concentrated along discrete, wavy, anastomosing bands; kyanite porphyroblasts (5%) are concentrated along discrete but discontinuous layers.

ANALYTICAL METHODOLOGY

Samples were pulverized into fragments approximately 0.25 mm in size, then washed and dried. Heavy minerals were concentrated using a Wilfley™ table, passed through methylene iodide for separation of the heavy-mineral concentrate, and then washed in de-ionized water and dried. Zircon was separated according to paramagnetic behaviour using a Frantz™ isodynamic magnetic separator. Roughly 100 grains were selected at random from among the nonmagnetic and least-magnetic fractions.

Each sample of detrital zircons was arranged along with fragments of the GSC laboratory zircon standard (Kipawa zircon, 993 Ma), cast in an epoxy grain mount (GSC no. IP67 and IP122), and polished sufficiently with diamond compound to reveal the grain centres. The zircon grains were photographed in transmitted and reflected light, cleaned, coated evaporatively with approximately 6.0 nm of high purity Au, and then imaged with a Cambridge Instruments scanning electron microscope, equipped with cathodoluminescence (CL) and backscatter electron (BSE) detectors in order to identify internal growth zoning features and fractures. Generally, the higher U domains of grain cores were targeted.

The U-Pb analyses were conducted using the GSC sensitive high-resolution ion microprobe (SHRIMP II). Beam diameter was approximately 20 µm. Analytical and data reduction procedures are described in detail by Stern (1997). Isotopic Pb/U ratios were corrected for interelement discrimination by reference to a linear calibration of the observed empirical covariation between $^{254}UO^+/^{238}U^+$ and $^{206}Pb^+/^{238}U^+$ obtained for the Kipawa zircon standard, with an external uncertainty of ±1.1% (1σ). Correction of the measured isotopic ratios for common Pb was estimated from monitored ^{204}Pb, and the corrected ratios and ages are shown in Table 1. Ages quoted in the text are the $^{207}Pb/^{206}Pb$ ages with 2σ errors.

Table 1. U-Pb analytical data, samples z5202, z5203, and z5947.

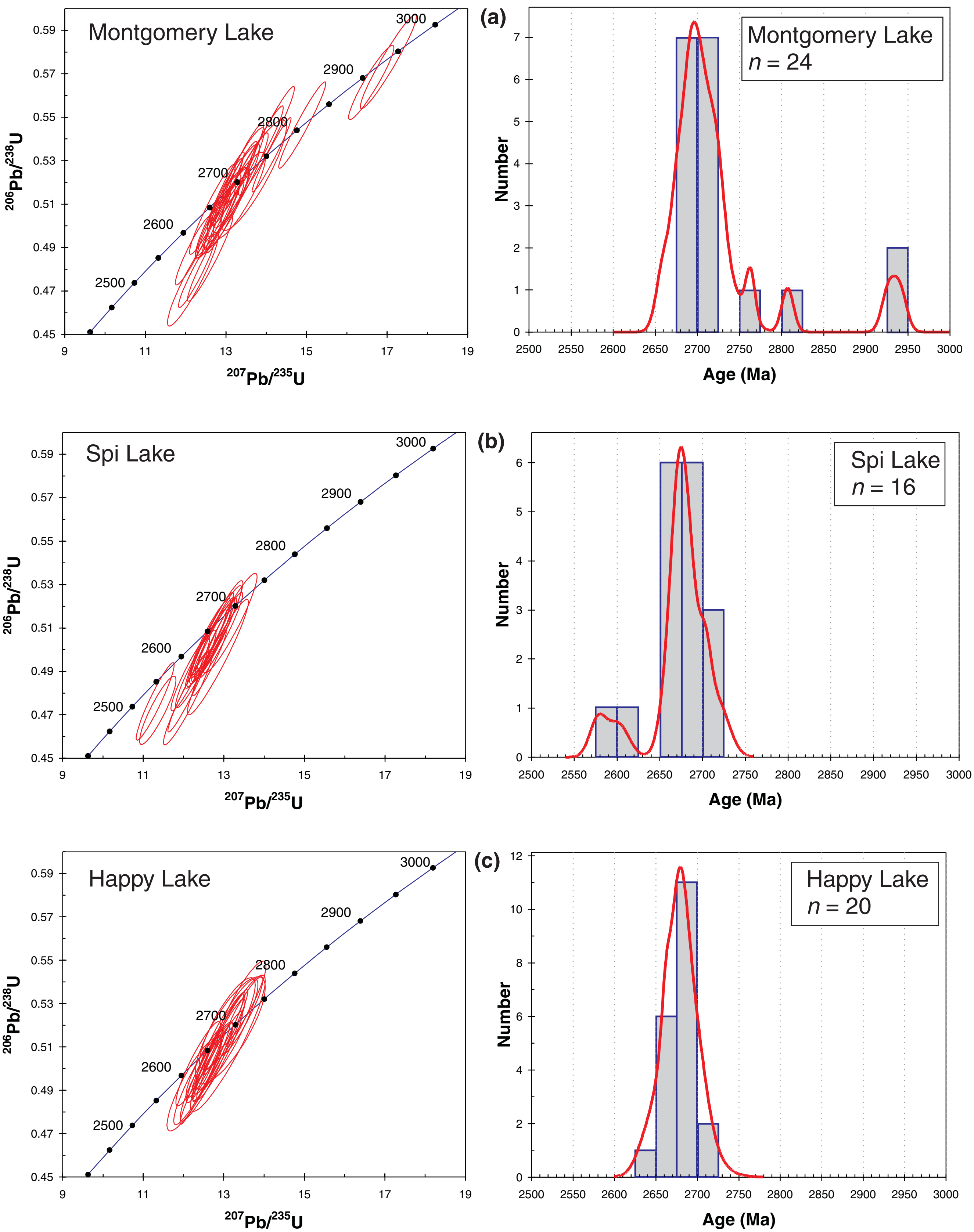
Labels[1]	U (ppm)	Th (ppm)	Th/U	Pb^2 (ppm)	^{204}Pb (ppb)	$^{204}Pb/^{206}Pb$	$\pm\,^{204}Pb/^{206}Pb^3$	$^{208}Pb/^{206}Pb$	$\pm\,^{208}Pb/^{206}Pb^3$	$^{206}Pb/^{238}U^4$	$\pm\,^{206}Pb/^{238}U^3$	$^{207}Pb/^{235}U^3$	$\pm\,^{207}Pb/^{235}U^3$	$^{207}Pb/^{206}Pb$	$\pm\,^{207}Pb/^{206}Pb^3$	Apparent Age (Ma) $^{206}Pb/^{238}U$	Apparent Age (Ma) $\pm\,^{206}Pb/^{238}U^3$	Apparent Age (Ma) $^{207}Pb/^{206}Pb$	Apparent Age (Ma) $\pm\,^{207}Pb/^{206}Pb^3$	Conc.[5] (%)
Sample z5203: Spi Group sandstone																				
Z5203-1.1	119	121	1.01	72	0	0.00001	0.00001	0.2868	0.0024	0.4807	0.0076	12.12	0.21	0.18282	0.00084	2530	33	2679	8	94.5
Z5203-2.1	203	96	0.47	114	1	0.00001	0.00001	0.1306	0.0010	0.4939	0.0062	12.64	0.17	0.18566	0.00073	2587	27	2704	7	95.7
Z5203-3.1	127	127	1.00	76	1	0.00002	0.00003	0.2837	0.0022	0.4762	0.0073	11.30	0.19	0.17206	0.00099	2511	32	2578	10	97.4
Z5203-4.1	103	94	0.92	64	1	0.00002	0.00002	0.2544	0.0020	0.5008	0.0073	12.57	0.20	0.18212	0.00089	2617	31	2672	8	97.9
Z5203-5.1	304	71	0.23	86	98	0.00145	0.00007	0.1226	0.0030	0.2532	0.0034	5.99	0.10	0.17168	0.00137	1455	18	2574	13	56.5
Z5203-6.1	40	18	0.46	22	0	0.00001	0.00001	0.1307	0.0032	0.4966	0.0109	12.85	0.31	0.18770	0.00141	2599	47	2722	12	95.5
Z5203-7.1	56	53	0.94	33	1	0.00003	0.00004	0.2655	0.0029	0.4783	0.0090	12.12	0.25	0.18379	0.00123	2520	39	2687	11	93.8
Z5203-8.1	92	68	0.74	56	0	0.00001	0.00001	0.2060	0.0021	0.5098	0.0081	12.88	0.23	0.18331	0.00106	2656	35	2683	10	99.0
Z5203-9.1	117	133	1.14	76	1	0.00002	0.00003	0.3174	0.0032	0.5060	0.0072	12.67	0.20	0.18163	0.00108	2639	31	2668	10	98.9
Z5203-10.1	64	44	0.69	39	0	0.00001	0.00001	0.1948	0.0026	0.5067	0.0081	12.92	0.22	0.18491	0.00096	2642	35	2697	9	98.0
Z5203-11.1	248	188	0.76	124	11	0.00013	0.00002	0.2207	0.0015	0.4186	0.0056	9.47	0.14	0.16416	0.00081	2254	26	2499	8	90.2
Z5203-12.1	119	123	1.03	74	1	0.00002	0.00002	0.2886	0.0023	0.4911	0.0073	12.31	0.21	0.18173	0.00107	2576	32	2669	10	96.5
Z5203-13.1	153	239	1.57	108	1	0.00001	0.00001	0.4361	0.0032	0.5076	0.0067	12.81	0.19	0.18304	0.00094	2646	29	2681	9	98.7
Z5203-14.1	97	64	0.66	58	0	0.00000	0.00002	0.1858	0.0018	0.5030	0.0073	12.70	0.20	0.18307	0.00095	2627	31	2681	9	98.0
Z5203-15.1	53	49	0.93	34	1	0.00002	0.00003	0.2636	0.0029	0.5081	0.0097	12.81	0.27	0.18290	0.00123	2648	42	2679	11	98.8
Z5203-16.1	132	37	0.28	73	1	0.00001	0.00001	0.0789	0.0013	0.5053	0.0076	12.80	0.21	0.18369	0.00101	2636	33	2686	9	98.1
Z5203-17.1	44	24	0.56	26	0	0.00001	0.00004	0.1555	0.0031	0.5122	0.0094	13.16	0.27	0.18626	0.00143	2666	40	2709	13	98.4
Z5203-18.1	102	55	0.54	55	0	0.00001	0.00002	0.1512	0.0021	0.4721	0.0064	11.36	0.18	0.17454	0.00129	2493	28	2602	12	95.8
Z5203-19.1	170	110	0.65	98	1	0.00001	0.00002	0.1839	0.0019	0.4892	0.0071	12.17	0.20	0.18043	0.00102	2567	31	2657	9	96.6
Z5203-19.2	136	125	0.92	85	3	0.00005	0.00002	0.2576	0.0021	0.5066	0.0081	12.70	0.22	0.18186	0.00089	2642	35	2670	8	99.0
Z5203-20.1	68	52	0.78	41	0	0.00001	0.00002	0.2164	0.0022	0.5042	0.0090	12.65	0.24	0.18188	0.00100	2632	39	2670	9	98.6
Sample z5202: Happy lake quartzite																				
Z5202-1.1	168	95	0.56	100	1	0.00001	0.00001	0.1567	0.0015	0.5162	0.0078	13.01	0.21	0.18272	0.00085	2683	33	2678	8	100.2
Z5202-2.1	112	64	0.57	67	0	0.00001	0.00001	0.1579	0.0014	0.5168	0.0073	13.00	0.20	0.18243	0.00096	2685	31	2675	9	100.4
Z5202-3.1	62	56	0.90	41	0	0.00001	0.00004	0.2531	0.0035	0.5297	0.0082	13.44	0.25	0.18401	0.00158	2740	34	2689	14	101.9
Z5202-4.1	139	65	0.47	79	1	0.00001	0.00001	0.1316	0.0013	0.5030	0.0074	12.73	0.20	0.18360	0.00083	2627	32	2686	7	97.8
Z5202-5.1	41	27	0.65	24	0	0.00001	0.00001	0.1816	0.0028	0.4929	0.0089	12.25	0.27	0.18031	0.00196	2583	38	2656	18	97.3
Z5202-6.1	21	17	0.81	13	1	0.00011	0.00012	0.2162	0.0057	0.5176	0.0101	13.16	0.36	0.18436	0.00302	2689	43	2692	27	99.9
Z5202-7.1	65	34	0.51	39	1	0.00002	0.00004	0.1425	0.0024	0.5208	0.0087	13.09	0.28	0.18228	0.00217	2702	37	2674	20	101.1
Z5202-8.1	57	34	0.61	34	0	0.00001	0.00001	0.1702	0.0019	0.5123	0.0099	12.94	0.27	0.18316	0.00105	2666	42	2682	10	99.4
Z5202-9.1	116	116	1.00	73	0	0.00001	0.00003	0.2748	0.0028	0.5023	0.0080	12.36	0.23	0.17854	0.00133	2624	34	2639	12	99.4
Z5202-10.1	272	241	0.89	166	1	0.00001	0.00001	0.2472	0.0019	0.4973	0.0094	12.53	0.25	0.18271	0.00090	2602	41	2678	8	97.2
Z5202-11.1	92	32	0.35	53	1	0.00002	0.00003	0.0972	0.0018	0.5243	0.0074	13.44	0.22	0.18589	0.00121	2717	31	2706	11	100.4
Z5202-12.1	285	275	0.97	180	1	0.00000	0.00001	0.2686	0.0012	0.5051	0.0061	12.60	0.16	0.18097	0.00050	2636	26	2662	5	99.0
Z5202-13.1	83	65	0.79	50	1	0.00002	0.00004	0.2175	0.0036	0.4986	0.0093	12.57	0.27	0.18286	0.00149	2608	40	2679	14	97.3

[1] labels identify grain number on mount; number after decimal indicates spot number
[2] radiogenic Pb
[3] uncertainties (±) given at 1σ absolute and calculated by numerical propogation of all known error (Stern 1997)
[4] Pb/U ratios corrected for measurement bias relative to Kipawa zircon standard (993 Ma); uncertainty in calibration of standard is ±1.1%
[5] 100 x ($^{206}Pb/^{238}U$ age)/($^{207}Pb/^{206}Pb$ age)

Table 1 (cont.)

Labels[1]	U (ppm)	Th (ppm)	Th/U	Pb^2 (ppm)	^{204}Pb (ppb)	$^{204}Pb/^{206}Pb$	$\pm ^{204}Pb/^{206}Pb^3$	$^{208}Pb/^{206}Pb$	$\pm ^{208}Pb/^{206}Pb^3$	$^{206}Pb/^{238}U^4$	$\pm ^{206}Pb/^{238}U^3$	$^{207}Pb/^{235}U^3$	$\pm ^{207}Pb/^{235}U^3$	$^{207}Pb/^{206}Pb$	$\pm ^{207}Pb/^{206}Pb^3$	Apparent Age (Ma) $^{206}Pb/^{238}U$	$\pm ^{206}Pb/^{238}U^3$	$^{207}Pb/^{206}Pb$	$\pm ^{207}Pb/^{206}Pb^3$	Conc.[5] (%)
Sample z5202: Happy lake quartzite (cont.)																				
Z5202-14.1	125	185	1.48	86	1	0.00001	0.00001	0.4148	0.0023	0.5024	0.0065	12.52	0.19	0.18072	0.00111	2624	28	2659	10	98.7
Z5202-15.1	104	126	1.22	68	0	0.00001	0.00001	0.3348	0.0022	0.5010	0.0068	12.54	0.19	0.18159	0.00095	2618	29	2667	9	98.1
Z5202-16.1	66	60	0.92	41	0	0.00001	0.00001	0.2610	0.0023	0.5061	0.0083	12.90	0.23	0.18484	0.00103	2640	36	2697	9	97.9
Z5202-17.1	68	65	0.96	43	0	0.00001	0.00001	0.2675	0.0024	0.5087	0.0096	12.88	0.27	0.18358	0.00119	2651	41	2686	11	98.7
Z5202-18.1	79	68	0.86	48	0	0.00001	0.00004	0.2428	0.0032	0.4948	0.0085	12.35	0.24	0.18106	0.00145	2591	37	2663	13	97.3
Z5202-19.1	21	12	0.58	12	0	0.00001	0.00001	0.1659	0.0047	0.5117	0.0128	13.10	0.38	0.18570	0.00216	2664	55	2704	19	98.5
Z5202-20.1	49	33	0.68	30	0	0.00000	0.00005	0.1898	0.0039	0.5158	0.0104	13.08	0.31	0.18386	0.00198	2681	44	2688	18	99.8
Sample z5947: Montgomery Group sandstone																				
122MG-1.1	157	122	0.77	102	1	0.00001	0.00001	0.2141	0.0012	0.5327	0.0070	14.13	0.20	0.19242	0.00064	2753	29	2763	6	99.6
122MG-2.1	117	101	0.86	69	0	0.00001	0.00001	0.2430	0.0017	0.4780	0.0064	12.26	0.18	0.18609	0.00088	2519	28	2708	8	93.0
122MG-4.1	156	164	1.05	102	5	0.00007	0.00002	0.2844	0.0017	0.5179	0.0066	13.02	0.18	0.18230	0.00068	2690	28	2674	6	100.6
122MG-5.1	108	58	0.54	60	0	0.00001	0.00001	0.1481	0.0017	0.4851	0.0081	12.61	0.23	0.18851	0.00101	2550	35	2729	9	93.4
122MG-6.1	41	30	0.72	26	0	0.00001	0.00001	0.2132	0.0030	0.5139	0.0082	13.33	0.26	0.18816	0.00188	2673	35	2726	17	98.1
122MG-7.1	50	26	0.52	29	0	0.00001	0.00001	0.1423	0.0020	0.5079	0.0077	13.03	0.23	0.18605	0.00133	2648	33	2708	12	97.8
122MG-8.1	124	56	0.45	83	1	0.00001	0.00001	0.1243	0.0014	0.5756	0.0088	17.03	0.28	0.21460	0.00105	2931	36	2941	8	99.7
122MG-9.1	63	69	1.10	40	0	0.00001	0.00001	0.2984	0.0033	0.5045	0.0079	12.81	0.23	0.18411	0.00132	2633	34	2690	12	97.9
122MG-10.1	42	33	0.78	24	0	0.00001	0.00001	0.2218	0.0030	0.4755	0.0089	12.18	0.26	0.18580	0.00150	2508	39	2705	13	92.7
122MG-12.1	40	28	0.69	25	0	0.00002	0.00004	0.1934	0.0030	0.5233	0.0104	13.69	0.33	0.18973	0.00220	2713	44	2740	19	99.0
122MG-13.1	105	79	0.76	63	0	0.00001	0.00001	0.2089	0.0023	0.5037	0.0068	12.89	0.19	0.18555	0.00084	2630	29	2703	8	97.3
122MG-14.1	95	46	0.48	54	0	0.00001	0.00001	0.1344	0.0020	0.5020	0.0070	12.74	0.20	0.18411	0.00109	2622	30	2690	10	97.5
122MG-17.1	161	47	0.29	101	1	0.00001	0.00001	0.0788	0.0011	0.5660	0.0070	16.61	0.23	0.21278	0.00103	2891	29	2927	8	98.8
122MG/18.1	63	47	0.75	40	0	0.00001	0.00001	0.2104	0.0024	0.5220	0.0085	13.46	0.24	0.18700	0.00109	2708	36	2716	10	99.7
122MG/19.1	153	172	1.12	100	1	0.00001	0.00001	0.3236	0.0016	0.5011	0.0060	12.70	0.17	0.18384	0.00076	2619	26	2688	7	97.4
122MG/20.1	121	76	0.63	78	7	0.00012	0.00002	0.1697	0.0014	0.5464	0.0081	14.89	0.24	0.19769	0.00084	2810	34	2807	7	100.1
122MG/21.1	111	111	1.00	68	34	0.00073	0.00004	0.2683	0.0022	0.4887	0.0065	12.19	0.18	0.18094	0.00096	2565	28	2661	9	96.4
122MG/22.1	74	107	1.45	53	0	0.00001	0.00001	0.4017	0.0033	0.5274	0.0073	13.43	0.22	0.18468	0.00121	2730	31	2695	11	101.3
122MG-23.1	62	40	0.64	39	1	0.00004	0.00002	0.1784	0.0020	0.5392	0.0102	14.01	0.28	0.18840	0.00098	2780	43	2728	9	101.9
122MG-24.1	53	56	1.05	35	0	0.00001	0.00001	0.2862	0.0025	0.5238	0.0097	13.29	0.27	0.18402	0.00103	2715	41	2689	9	101.0
122MG-26.1	83	46	0.55	50	0	0.00000	0.00002	0.1543	0.0015	0.5219	0.0069	13.30	0.20	0.18476	0.00089	2707	29	2696	8	100.4
122MG-31.1	169	142	0.84	106	1	0.00001	0.00001	0.2333	0.0014	0.5150	0.0066	12.98	0.18	0.18273	0.00070	2678	28	2678	6	100.0
122MG-39.1	126	83	0.66	80	1	0.00001	0.00001	0.1857	0.0019	0.5388	0.0067	13.96	0.19	0.18786	0.00082	2778	28	2723	7	102.0
122MG-46.1	125	140	1.12	83	1	0.00002	0.00002	0.3174	0.0027	0.5110	0.0065	13.05	0.21	0.18520	0.00153	2661	28	2700	14	98.5
122MG-67.1	83	33	0.40	47	0	0.00001	0.00001	0.1119	0.0014	0.5076	0.0085	12.66	0.23	0.18095	0.00103	2646	36	2662	9	99.4
122MG-78.1	157	124	0.79	95	1	0.00001	0.00001	0.2179	0.0012	0.5043	0.0068	12.98	0.19	0.18669	0.00087	2632	29	2713	8	97.0
122MG-81.1	64	48	0.75	40	1	0.00002	0.00003	0.2079	0.0022	0.5184	0.0079	13.26	0.24	0.18552	0.00137	2692	34	2703	12	99.6

[1] labels identify grain number on mount; number after decimal indicates spot number
[2] radiogenic Pb
[3] uncertainties (±) given at 1σ absolute and calculated by numerical propogation of all known error (Stern 1997)
[4] Pb/U ratios corrected for measurement bias relative to Kipawa zircon standard (993 Ma); uncertainty in calibration of standard is ±1.1%
[5] 100 x ($^{206}Pb/^{238}U$ age)/($^{207}Pb/^{206}Pb$ age)


Montgomery Lake
(a)
Montgomery Lake
n = 24
$^{206}Pb/^{238}U$
$^{207}Pb/^{235}U$
Number
Age (Ma)
Spi Lake
(b)
Spi Lake
n = 16
$^{206}Pb/^{238}U$
$^{207}Pb/^{235}U$
Number
Age (Ma)
Happy Lake
(c)
Happy Lake
n = 20
$^{206}Pb/^{238}U$
$^{207}Pb/^{235}U$
Number
Age (Ma)

RESULTS

Montgomery Group sandstone

Detrital zircon grains in the sample generally do not exceed 100 µm in length and are typically euhedral to subhedral with fine preservation of crystal facets. Fine oscillatory growth zoning, typical of igneous zircons, is observed in CL images of most of the grains; overgrowths occur on several grains but these were not analyzed. Of the 27 grains that were analyzed, 24 are less than 5% discordant and are therefore considered to provide a close approximation of the crystallization age of the protolith from which the zircon was derived. Most of the grains (21) fall within an age range varying between 2730 and 2660 Ma, with a significant mode at ca. 2690 Ma (Fig. 2a; Table 1). Three grains are older, with ages of 2763 ± 24 Ma, 2807 ± 28 Ma, and 2927 ± 32 Ma. The older grains are morphologically indistinguishable from those in the younger cluster.

Spi Group sandstone

At least 70% of the zircon grains in this sample are large (150–200 µm), well rounded, surface pitted, and pink. The remaining grains consist of subequal amounts of angular, broken grains and those with well-preserved crystal facets. The well-rounded grains display fine oscillatory zoning in CL; broad sector zoning is exhibited by some of the more angular grains. Thin overgrowths, observed in two or three grains, were not analyzed. Of the 20 grains analyzed, 16 are less than 5% discordant and 13 grains are within an age range of 2710 to 2660 Ma. The dominant mode illustrated in the cumulative probability plot is about 2675 Ma. (Fig. 2b; Table 1). Two distinctly younger grains were documented at 2578 ± 20 Ma and 2602 ± 24 Ma; both are very well rounded, suggesting a distal or second-cycle source.

Happy lake quartzite

The zircons in this sample are mostly euhedral, with well-preserved crystal facets, and vary in length from 100 to 250 µm. Most grains display fine oscillatory zoning in CL; others show complex sector zoning with thin metamorphic overgrowths. Twenty analyses of detrital zircon grains provided concordant U-Pb data and yielded a range of ages from 2710 to 2640 Ma, with a distinct mode at about 2680 Ma (Fig. 2; Table 1). There seems to be no correlation between age and internal morphology.

DISCUSSION AND CONCLUSIONS

The ages of detrital zircons from these three sedimentary units demonstrate mainly local provenance from underlying volcanoplutonic belts of Neoarchean age and that the units are younger than ca. 2.66 Ga. In this respect, they are similar to the Wilson River conglomerate in the Tavani area, to the east, where detrital zircons as young as 2.65 Ga were recovered (Davis and Peterson, 1998). Unfortunately, with the exception of the Spi Group, the detrital zircon ages are inconclusive for distinguishing late Neoarchean from Paleoproterozoic depositional ages. This may be due, in part, to the relatively small number of zircon analyses carried out in this study.

The U-Pb ages of detrital zircons in the Montgomery Group sample do not help to better constrain its stratigraphic position. The detrital zircon age profile of the Montgomery Group is similar to that of the unconformably overlying lower Hurwitz Group (cf. Davis et al., 1999). As such, the Montgomery Group represents either a late Neoarchean molasse-like sequence, developed late in the history of the Henik–Kaminak–Tavani greenstone belt (analogous to the Jackson Lake Formation in the Slave Province [e.g. Padgham and Fyson, 1992] or the Timiskaming Group in the Superior Province [e.g. Thurston and Chivers, 1990]), or a Paleoproterozoic precursor to the Hurwitz Group (Aspler et al., 1992).

Detrital zircon ages from the Spi Group are similar to those of the Montgomery Group, except for two relatively young grains (2578 ± 20 Ma and 2602 ± 24 Ma). The younger ages are significant, as they indicate a post ca. 2600 Ma depositional age that confirms the Spi Group to be considerably younger than the ca. 2.7 Ga Kaminak Group (Beavon, 1976; Patterson, 1991; Davis et al., 1999). The data are consistent with the unit being deposited in a rift basin at the time of the Kaminak mafic magmatic event, as suggested by the geochemistry of the associated mafic volcanic rocks (e.g. Beavon, 1976; Patterson, 1991; Sandeman et al., 2000). Late Archean (2630–2570 Ma) plutons are not documented in the immediate area, but must have been unroofed elsewhere, with detritus being carried into the rift basins.

The Happy lake quartzite has a detrital zircon age profile similar to those of the other two samples, with the exception that no ca. 2.6 Ga grains were documented. The strong mode at 2680 Ma, combined with the euhedral morphology of most of the grains, suggests local provenance from the nearby Kaminak Group, where felsic volcanic rocks and related intrusions of this age are common (Davis et al., 1999). The detrital zircon age data indicate that the quartzite is younger than the Kaminak Group, but otherwise do not help to constrain its age or relative stratigraphic position. A similar

__Figure 2 (opposite).__ Summary of single-grain SHRIMP U-Pb detrital zircon ages for the three sandstone samples analyzed in this study (from data listed in Table 1): __a)__ Montgomery Group sandstone (sample z5947), __b)__ Spi Group conglomerate (sample z5203), and __c)__ Happy lake quartzite (sample z5202). Plots on the left are concordia curves (2σ errors) and those on the right are histograms of $^{207}Pb/^{206}Pb$ ages with superimposed Gaussian probability density curves. Bin interval of histograms is 25 Ma. Data screened for <5% discordance.

detrital zircon age profile typifies samples of the Paleoproterozoic lower Hurwitz Group (Davis et al., 2000). The Happy lake quartzite is unlikely to be part of the upper Hurwitz Group because it does not contain any Paleoproterozoic detrital zircon, characteristic of that succession elsewhere (cf. Davis et al., 2000). The aluminous (kyanite-rich) composition of the Happy lake quartzite is uncharacteristic of Archean rocks from this region and suggests rigorous chemical weathering during deposition of the protolith in a relatively stable tectonic setting (Young and Nesbitt, 1998). Aluminous minerals are common in the lower Hurwitz Group and potentially correlative sequences throughout North America (Young, 1973). Although it is speculative to make a stratigraphic assignment based solely on lithology, correlation of the Happy lake quartzite with the lower Hurwitz Group remains a viable, and arguably the preferred hypothesis.

ACKNOWLEDGMENTS

We thank Richard Stern and Natalie Morisset for their help in acquiring the ion-microprobe data; and Nicole Rayner and Richard Stern for suggestions on how improve the manuscript. Samples were prepared by Gerry Gagnon and Ron Christie. The work described in this report was carried out as part of geochronology project P7.

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