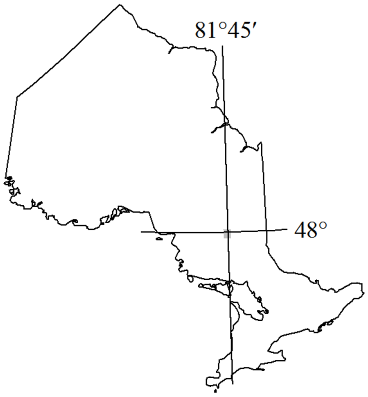

43. A “New” Occurrence of Timiskaming Sedimentary Rocks in the Northern Swayze Greenstone Belt, Abitibi Subprovince— With Implications for the Western Continuation of the Porcupine–Destor Fault Zone and Nearby Gold Mineralization

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INTRODUCTION

A century of discovery, exploration, shaft sinking and mine production has demonstrated a strong empirical relationship between economic gold mineralization and some of the principal faults in the Abitibi greenstone belt. Early generations of geologists called these major faults “the breaks” because no major map units could be mapped across these faults, at least not without major offset. Protracted activity on these principal faults is further demonstrated by the fact that not even latest Archean plutons can be mapped across them—in other words, there is not a single “stitching pluton” known to the authors. The first units to cut across the breaks are the approximately north-trending Matachewan diabase dikes, the oldest pulse of which has a precise age of 2479±4 Ma (Bleeker et al. 2012).

In the Timmins area, also known as the classical Porcupine mining camp, some of Canada’s largest Archean lode gold deposits (e.g., Hollinger, McIntyre and Dome) occur within or adjacent to one of the major breaks—the Porcupine–Destor fault zone (PDFZ). At least 72.5 million ounces of gold have been produced from this area, and greater than 98% of this mineralization has come from one side of the fault, the north side (e.g., Table 43.1; *see also* Bleeker 1995, Figure 11), from veins within a panel of synorogenic clastic rocks locally known as the Timiskaming Group or assemblage, veins straddling the unconformity at the base of this clastic package, or from veins hosted by deformed greenstones and porphyry intrusions below this synorogenic unconformity—but all within approximately 0.1 to 3 km from the major fault zone. A similar setup occurs further south, in the Larder Lake–Kirkland Lake mining camp, and elsewhere in the Abitibi greenstone belt, the Superior craton, or the Canadian Shield (e.g., Yellowknife). This has led, again empirically, to the recognition that panels of synorogenic clastic rocks, in addition to large regional faults, are a critical ingredient of large Archean gold camps. A third essential ingredient appears to be synorogenic mantle-driven magmatism, typically syenites and allied rocks, and diagnostically important but volumetrically trivial lamprophyre dike swarms (*see also* Wyman and Kerrich 1988; Robert 2001; and additional references therein).

Summary of Field Work and Other Activities 2014,
Ontario Geological Survey, Open File Report 6300, p.43-1 to 43-10.

Table 43.1. This summary of Ontario gold production in the vicinity of the Porcupine–Destor fault zone, to the end of 2013, shows that a total of 93.6% of the gold has been mined from the north side of the fault, with less than 2% obtained south of the fault. An additional 4.6% was obtained either from within the fault or in such close proximity, that its relative position to the fault is uncertain.

Mine	Township	Years of Production	Tons Milled	Production (ounces gold)	Grade[1] (oz/ton)	Position Relative to PDFZ[2]
Aljo	Beatty	1940	2333	42	0.018	N
American Eagle	Munro	1911	60	40	0.667	N
Ankerite/March	Deloro	1926−1935	317 769	61 039	0.19	N
Aquarius	Macklem	1984, 1988–1989	139 634	27 117	0.19	S
Argyll	Beatty	1918	12 455	851	0.068	?
Aunor (Pamour #3)	Deloro	1940–1984	8 482 174	2 502 214	0.30	N
Banner	Whitney	1927–1928, 1933, 1935	315	670	0.13	N
Bell Creek	Hoyle	1987–1991, 1992–1994,	576 017	112 739	0.196	N
		2011–2013	609 670	74 825	0.127	
Black Fox (Glimmer)	Hislop	1997–2001, 2009–2013	5 020 823	561 645	0.112	?
Blue Quartz	Beatty	1923, 1926, 1928, 1934	500	81	0.162	N
Bonetal	Whitney	1941–1951	352 254	51 510	0.15	N
Bonwhit	Whitney	1951–1954	200 555	67 940	0.34	N
Broulan Porcupine	Whitney	1939–1953	1 146 059	243 757	0.21	N
Broulan Reef Mine	Whitney	1915–1965	2 144 507	498 932	0.23	N
Buffalo Ankerite	Deloro	1926–1953, 1978	4 993 929	957 292	0.19	N
Buffonta	Garrison	1981, 1991–1992	117 013	12 139	0.104	S
Canadian Arrow	Hislop	1974–1976, 1980–1983	303 449	19 140	0.063	S
Canamax Matheson project	Holloway	1988	38 675	5391	0.139	?
Centre Hill	Munro	1967–1970	327 007	422	0.001	N
Cincinnati	Deloro	1914, 1922–1924	3200	736	0.23	N
Clavos	Stock	2005–2007	188 743	24 609	0.13	N
Concordia	Deloro	1935	230	16	0.07	S
Coniarum/Carium	Tisdale	1913–1918, 1928–1961	4 464 006	1 109 574	0.25	N
Croesus	Munro	1915–1918, 1923, 1931–1936	5333	14 859	2.786	N
Crown	Tisdale	1913–1921	226 180	138 330	0.61	N
Davidson–Tisdale	Tisdale	1918–1920, 1988	53 221	9739	0.18	N
Delnite	Deloro	1937–1964	3 847 364	920 404	0.24	N
(open pit)		1987–1988	56 067	3602	0.064	
DeSantis	Ogden	1933, 1939–1942, 1961–1964	196 928	35 842	0.18	N
Dome	Tisdale	1910–2013	114 624 858	16 361 420	0.143	N
Faymar	Deloro	1940–1942	119 181	21 851	0.180	S
Fuller (Vedron)	Tisdale	1940–1944	44 028	6566	0.15	N
Gillies Lake	Tisdale	1921–1931, 1935–1937	54 502	15 278	0.28	N
Goldhawk	Cody	1947	636	53	0.08	S
(open pit)		1980	40 000	3967	0.10	
Goldpost	Hislop	1989	9403	2913	0.310	S
Gold Pyramid	Guibord	1911	175	36	0.206	N
Hallnor (Pamour #2)	Whitney	1938–1968, 1981	4 226 419	1 645 892	0.39	N
Hislop (Hislop East)	Hislop	1990–1991, 1993–1995, 1999–2000, 2007, 2010–2013	1 992 346	124 373	0.062	?
Hollinger–Schumacher	Tisdale	1915–1918	112 124	27 182	0.24	N
Hollinger	Tisdale	1910–1968	65 778 234	19 327 691	0.29	N
Pamour Timmins property		1976–1988	2 615 866	182 058	0.07	
Holloway	Holloway	1993, 1995, 1996–2006, 2011–2013	6 091 733	946 384	0.155	?
Holloway–Holt	Holloway	2007–2010	601 778	89 703	0.149	?
Holt	Holloway	1988–2004, 2011–2013	9 191 442	1 409 473	0.153	?

***Notes**:* [1] *Grade: ounce per ton gold; N/A = data not available.*
All tonnages have been converted to Imperial units using a conversion factor of 1.1023113.
[2] *Position relative to the Porcupine–Destor fault zone: N – north side; S – south side; ? uncertain location relative to the PDFZ.*

Table 43.1, continued.

Mine	Township	Years of Production	Tons Milled	Production (ounces gold)	Grade[1] (oz/ton)	Position Relative to PDFZ[2]
Hoyle–Falconbridge	Whitney	1941–1944, 1946–1949	725 494	71 843	0.10	N
Hoyle Pond	Hoyle	1985–2013	9 215 939	3 233 793	0.35	N
Hugh–Pam	Whitney	1926, 1948–1965	636 751	119 604	0.19	N
Marlhill	Hoyle	1989–1991	156 800	30 924	0.197	N
McIntyre Pamour Schumacher (ERG tailings recovery)	Tisdale	1912–1988 1988–1989	37 634 691 2 549 189	10 751 941 18 260	0.29 0.007	N
McLaren	Deloro	1933–1937	876	201	0.23	N
Moneta	Tisdale	1938–1943	314 829	149 250	0.47	N
Naybob (Kenilworth)	Ogden	1932–1964	304 100	50 731	0.17	?
Newfield	Garrison	1996	55 000	9680	0.176	?
Nighthawk	Macklem	1995–1999	1 479 607	175 803	0.12	S
Owl Creek	Hoyle	1981–1989	1 984 400	236 880	0.12	N
Pamour # 1 (incl. pits 3, 4 and 7 and Hoyle)	Whitney	1936–1999 2005–2011	45 795 863 17 750 312	4 078 525 698 771	0.09 0.036	N
Pamour (other sources)	Whitney	1936–1999	7 416 634	676 645	0.091	N
Paymaster	Deloro	1915–1919, 1922–1966	5 607 402	1 192 206	0.21	N
Porcupine Lake (Hunter)	Whitney	1937–1940, 1944	10 821	1369	0.13	?
Porcupine Peninsular	Cody	1924–1927, 1940, 1947	99 688	27 354	0.27	S
Preston	Tisdale	1938–1968	6 284 405	1 539 355	0.24	N
Preston NY	Tisdale	1933	2800	153	0.05	N
Preston/Porcupine Pet	Deloro	1914–1915	1000	314	N/A	N
Preston/Porphyry Hill	Deloro	1913–1915	46	312	6.78	N
Ross	Hislop	1936–1989	6 714 482	995 832	0.148	S
Stock	Stock	1989–1994, 2000	821 304	129 856	0.16	?
Taylor	Taylor	2007	19 259	2043	0.106	?
Timmins West	Bristol	2009–2013	2 108 651	308 298	0.15	N
Tisdale Ankerite	Tisdale	1952	14 655	2236	0.15	N
Tommy Burns/Arcadia	Shaw	1917	21	14	0.66	S
Triple Lake	McArthur	1932	155	121	0.78	S
Vipond	Tisdale	1911–1941	1 565 218	414 367	0.26	N
White–Guyatt	Munro	1911	50	10	0.20	N
		Total	**388 599 637**	**72 537 028**	**0.187**	

Notes: *[1] Grade: ounce per ton gold; N/A = data not available.*
All tonnages have been converted to Imperial units using a conversion factor of 1.1023113.
[2] Position relative to the Porcupine–Destor fault zone: N – north side; S – south side; ? uncertain location relative to the PDFZ.

In a recent paper (Bleeker 2012), the critical roles of all these ingredients were synthesized into a single coherent model. In short, the major breaks were initiated as synorogenic, deep-reaching extensional faults. Lithospheric extension led to a flare-up in alkalic magmatism, and later contributed to synorogenic subsidence and basin formation. Crustal thinning, heating of the lower crust and the magmatic flare-up were key drivers of hydrothermal circulation. Renewed compression and inversion of the first-order extensional faults as thick-skinned thrusts then tectonically buried synorogenic clastic basin remnants, as well as upper crustal rocks with gold vein systems, into their structural footwalls, where they were preserved against approximately 10 to 15 km of postorogenic uplift and erosion. The breaks acted as the principal conduits between deep crustal fluid generation zones and upper crustal depositional environments, whereas the tectonically buried panels of synorogenic clastic rocks serve to indicate the principal faults that underwent major fault inversion. The synorogenic clastic rocks also indicate preservation of the critical upper crustal sections (of synorogenic age, i.e., the time of gold mineralization). Simply put, no preservation, no gold mineralization. Some of these aspects are illustrated in Figure 43.1 (*see* Bleeker 2012, for a series of diagrams that present the full model).

New discoveries of panels of preserved and demonstrably synorogenic clastic rocks are thus of critical importance to gold exploration in the Abitibi greenstone belt, particularly in areas where the lateral extension of one of the major breaks can be projected. Herein is described one such panel of synorogenic clastic rocks from the Penhorwood area, northern Swayze greenstone belt, approximately 66 km west-southwest of Timmins, in an area that the authors consider is likely to host the western extension of the PDFZ (Figure 43.2). New trenching by Rapier Gold Inc. was instrumental in improved exposure of these rocks. Sedimentary rocks in the area have long been known and Milne (1972a, 1972b, 1972c) does describe conglomerate from some of the outcrops.

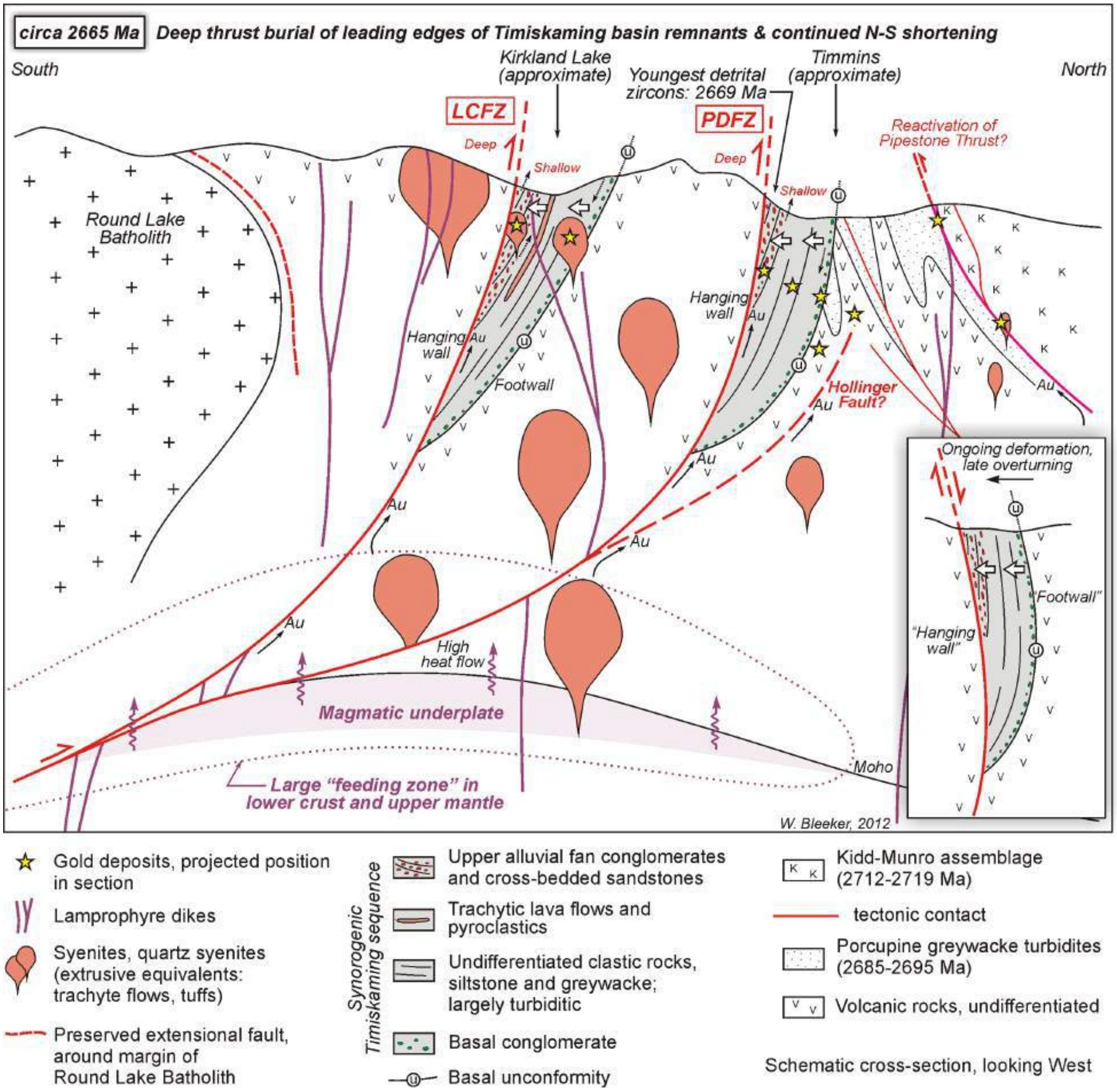

Figure 43.1. Schematic section through the Timmins area (Porcupine mining camp), looking west, showing the fundamental relationships between the principal faults (the "breaks"), initiated as extensional faults, but inverted as thick-skinned thrusts; preserved panels of synorogenic clastic rocks in their structural footwall; and syenitic plutons and gold mineralization (*modified from* Bleeker 2012). Bold white arrows indicate the stratigraphic younging direction of the synorogenic clastic rocks. Abbreviations: PDFZ, Porcupine–Destor fault zone; LCFZ, Larder–Cadillac fault zone.

SOME MORE BACKGROUND

Gold mineralization in the northern Swayze greenstone belt has been known for some time (Harding 1938; Ayer 1995). Exploration in this area was boosted by the discovery of quartz veins with visible gold in drill core, as part of exploration programs by Rio Tinto Minerals and Rapier Gold Inc. (Pope 2013a, 2013b, 2014). This led to new mapping and trenching in the area, which is located in proximity to Imerys' talc mine in Penhorwood and Reeves townships. The new trenches expose superb outcrops of the following lithologies: thinly layered dark sulphidic siltstones, polymict conglomerates, interbedded pebbly sandstones, and somewhat older intermediate to felsic plagioclase porphyry intrusions that cut deformed mafic metavolcanic rocks. Critical aspects of the interbedded conglomerates and pebbly sandstones, which will be described below, leave little doubt that these sedimentary rocks were deposited in a high-energy fluvial to fluvio-deltaic environment, in an overall synorogenic setting. Hence, they can be confidently classified as synorogenic clastic rocks of the Timiskaming assemblage of the Abitibi greenstone belt and are directly comparable to the Three Nations Formation of the Timiskaming sequence in the Porcupine mining camp.

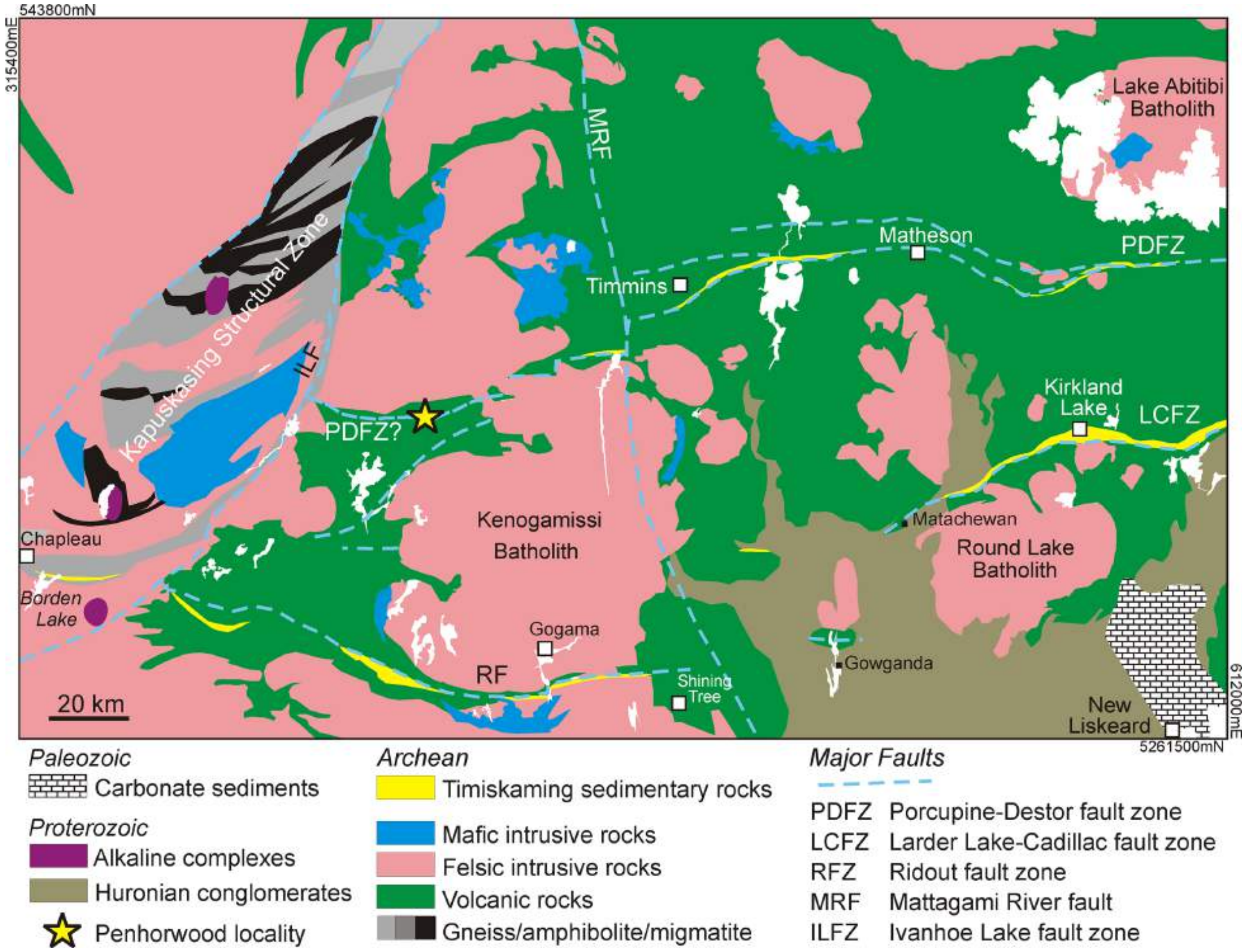

Figure 43.2. Simplified geology of the western Abitibi greenstone belt and the Kapuskasing Structural Zone highlighting the presence of known Timiskaming rocks. The yellow star identifies the location of the "new" occurrence of Timiskaming rocks in the northern part of the Swayze greenstone belt.

DESCRIPTION OF ROCK TYPES

Polymict Conglomerate and (Pebbly) Sandstone

The new trenches expose a steeply dipping (subvertical) package of metasedimentary rocks, perhaps approximately 100 m thick. The dominant rock type of this package is polymict conglomerate (Photo 43.1) with pebbles of 1 to 10 cm in size. A quick survey of clast types showed a variety of lithologies including

Photo 43.1. Outcrop pictures of synorogenic conglomerates and interbedded sandstones, Penhorwood area, northern Swayze greenstone belt. **A)** Outcrop of polymict conglomerate in new trenches. Geologist (Dave Glidden) for scale. **B)** Interbedded polymict conglomerate and (pebbly) sandstone, with decimetre-scale layering (pen for scale). This layering probably represents large-scale foresets on large dunes in a high-energy braided river or river delta. All aspects of these rocks are directly comparable to those of the Three Nations Formation, uppermost Timiskaming sequence in Timmins. **C)** Close-up of polymict pebble population. Note the variety of clast types, and superb rounding of many of the clasts. Fine-grained granitoid clast at arrow. Dashed line indicates flattening parallel to late cleavage (fabric). **D)** View on bedding or foliation surface, showing partial views of weathered-out clasts in 3 dimensions (at arrows), highlighting their rounding.

plagioclase porphyry and various other porphyries, a variety of mafic and felsic volcanic rocks, some fine- to medium-grained granitoids (e.g., Photo 43.1C), and some clasts of monomineralic vein quartz. The clasts of plagioclase porphyry likely represents locally derived detritus from nearby porphyry intrusions exposed in what must be the stratigraphic footwall. However, many other clast types also indicate a broader provenance. The majority of clasts are well rounded, and the pebble conglomerates are clast supported. Interbedded with these conglomerates are 5 to 30 cm thick sandstone layers, some with pebble lags. The scale of interbedding of the conglomerate and sandstone layers is suggestive of large foresets on dune-size ripples such as can be seen in the Three Nations Formation east of Timmins. Millimetre- to centimetre-scale lamination is locally preserved in the sandstone layers and suggests relict cross-bedding. Although more observations are needed, the authors' initial interpretation was, based on concavity of these laminations and local truncations (Photo 43.2), that this panel of synorogenic clastic rocks faces south (i.e., stratigraphic tops to the south), analogous to the Timiskaming panel in Timmins. Barring further complications, this would suggest the major fault that buried these synorogenic rocks occurs to the south and not to the north (e.g., the highly schistose mafic volcanic rocks along Highway 101 must represent another high strain zone). Alternatively, there could be more than one strand of the PDFZ, such as is seen in the area east of Matheson.

Dark-Coloured Siltstones

The northernmost trenches also expose some tens of metres of dark slaty siltstones. These fine-grained sedimentary rocks contain minor disseminated sulphides and weather rusty. Although in themselves these siltstones may not be diagnostic, their close and conformable association with the conglomerates and sandstones identifies them as part of the dark slates and siltstones that typify the

Photo 43.2. Interbedded polymict conglomerate and sandstone with somewhat irregular bedding and apparent truncation of a gravel bed with subsequent infilling by sandy sediment. Facing direction indicated by arrow is to top of the photo (southward). Location UTM 415138E 5337344N, NAD83, Zone 17.

middle part of the Timiskaming sequence in Timmins. If overall younging is indeed to the south, they would underlie the conglomerates–sandstones, as they do in Timmins. The siltstones could represent either temporal basin deepening prior to final basin filling by the uppermost conglomerates (*see* Bleeker 2012), or lacustrine or overbank deposits associated with a larger synorogenic river system.

Alteration

Some of these synorogenic clastic rocks were noticeably altered by incipient to strong rusty carbonate alteration, with many of the mafic to ultramafic volcanic clasts altered to greenish (fuchsitic?) schist. All these characteristics compare well with the Timmins area.

DISCUSSION AND TENTATIVE CONCLUSIONS

New trenching in the northern Swayze greenstone belt has led to better exposures of what can be recognized, unequivocally, as synorogenic clastic rocks that were deposited in a high-energy fluvial to fluvio-deltaic setting. The conglomerates are clast supported, well rounded and polymict, and they include a small proportion of granitoid clasts and quartz clasts, indicating that significant exhumation and erosion were going on in the drainage basin that sourced these conglomerates. Rounded clasts of plagioclase porphyry, similar to an intrusion exposed nearby (to the north), represent locally derived detritus. One granitoid clast contains a predepositional foliation at an angle to the postdepositional tectonic fabrics in the conglomerates and sandstones. The regular interlayering of clast-supported conglomerate layers and sandstone layers indicates deposition in a high-energy environment, as large foresets on dune-scale ripples in a large river or delta.

Preservation of this panel of synorogenic clastic rocks suggests one of the major faults, most likely the western extension of the PDFZ, must be nearby and buried these rocks in its structural footwall during the late thick-skinned thrusting phase. If younging direction is indeed to the south, as discussed above, the authors suggest that the principal fault or a major strand thereof occurs to the south of the clastic panel. In Timmins and in Kirkland Lake, the synorogenic clastic rocks invariably young into the faults that buried them (*see* Figure 43.1).

The Penhorwood area of the northern Swayze greenstone belt thus hosts gold mineralization, a major fault that almost certainly is the western continuation of the PDFZ, and a preserved panel of synorogenic clastic rocks. The full extent and width of the synorogenic clastic panel remains to be determined, but its size could be substantial (*cf.* Milne 1972b, 1972c). At present, the authors are not aware of associated alkalic intrusive rocks, but the knowledge base of this area is limited.

FUTURE WORK

Research and exploration in this area are ongoing. In addition to more detailed petrography, detrital zircon analyses of the well-mixed sandstones will be conducted to see whether young zircons (<2680 Ma) can be identified as part of the detrital input (but see caveats below). Further stripping and trenching in the area would be helpful, hopefully uncovering more robust younging directions and perhaps also a preserved unconformity (on the north side?). Integration of these new findings into existing regional geological and geophysical data is also needed, hopefully helping in identifying the major fault strands and the most likely continuation of the PDFZ. Once the overall polarity of this panel of synorogenic clastic rocks is better established, exploration should focus on its immediate stratigraphic footwall.

A WORD OF CAUTION ON DETRITAL ZIRCON GEOCHRONOLOGY OF SYNOROGENIC SEQUENCES

In the context of this report, and as a final word of caution, it is worth pointing out some of the pitfalls of detrital zircon geochronology ("dating"). Such analyses of a selection of detrital zircon grains separated from a well-mixed sandstone or conglomerate may or may not put a tight constraint on the depositional age of a clastic metasedimentary rock, and then only if the youngest single-grain analysis is concordant in U/Pb concordia space, or very nearly so. Ideally, a large number of grains would be analyzed by precise (isotope dilution thermal ionization mass spectrometry (ID-TIMS)) methods, but, in many cases, this is too time consuming and/or too expensive. Instrumental methods (sensitive high-resolution ion microprobe (SHRIMP) or laser ablation inductively coupled plasma mass spectrometry (LA-ICP–MS)) do allow for spot analyses of a large and statistically significant number of zircons, but generally do not provide the precision or resolution required (preferably better than *circa* 5 Ma) to resolve the question of whether a sandstone is synorogenic or part of an older sequence (e.g., Porcupine assemblage).

A smaller selection of zircon grains with precise age determinations (by ID-TIMS), although well resolved in time, may entirely miss a minor population of young and diagnostic zircon grains. For instance, the youngest grain analyzed could be *circa* 2690 Ma, leading some to suggest the sediment in question must belong to the Porcupine assemblage, whereas it may simply reflect a relative scarcity of young zircon grains derived from synorogenic plutonic sources. Depending on the source of a particular sediment, and the choice of sample (e.g., poorly mixed conglomerate versus a more inclusive sampling of well-mixed sandstone layers), a synorogenic clastic rock sample may completely lack diagnostic young zircon grains.

If an apparently young zircon grain is not fully concordant in U/Pb concordia space, it could be 5 to 10 million years older than its apparent ^{207}Pb/^{206}Pb age, depending on the complexity of the (early) Pb-loss history. In such a case, one is tempted to assign a young synorogenic age to a sedimentary rock that in fact may be significantly older. At least this particular complexity may now be minimized with the innovation of "chemical abrasion" (Mattinson 2005) prior to final dissolution and isotopic analysis of the zircons in question.

In the end, it is the overall rock association and sedimentological character, such as displayed in these new trenches in Penhorwood Township, that is more important. Zircons may or may not contribute to solving the depositional age of the sediment. First and foremost, they provide valuable information on the sources contributing to the clastic sediment, the degree of mixing and, thus, a rough indication of what must have been the scale of the river systems.

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