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RHYOLITIC COMPONENTS OF THE MICHIPICOTEN GREENSTONE BELT, ONTARIO: EVIDENCE FOR LATE ARCHEAN INTRACONTINENTAL RIFTS OR CONVERGENT PLATE MARGINS IN THE CANADIAN SHIELD?

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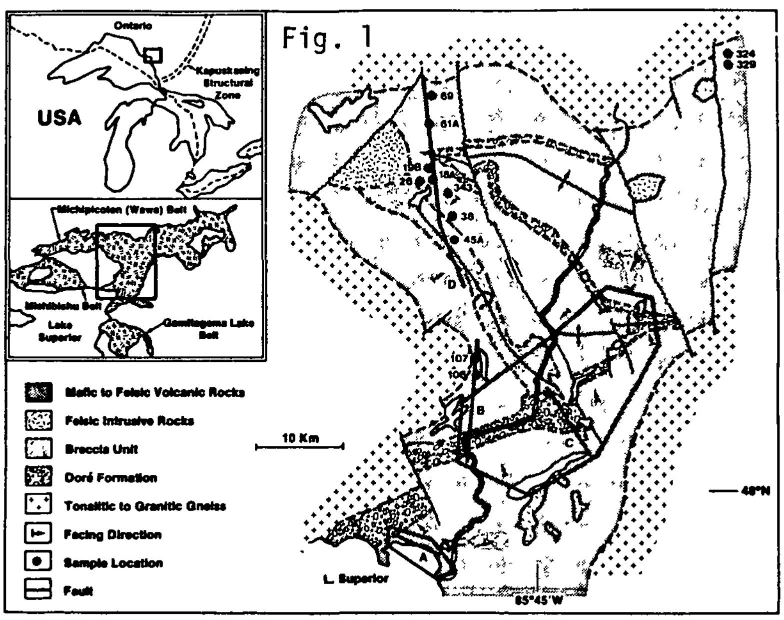
Rhyolitic rocks often are the dominant felsic end member of the bimodal volcanic suites that characterize many late Archean greenstone belts of the Canadian Shield [1]. The rhyolites primarily are pyroclastic flows (ash flow tuffs) emplaced following plinian eruptions [2], although deposits formed by lava flows and phreatomagmatic eruptions also are present. Based both on measured tectono-stratigraphic sections and provenance studies of greenstone belt sedimentary sequences [3], the rhyolites are believed to have been equal in abundance to associated basaltic rocks.

In many recent discussions of the tectonic setting of late Archean Canadian greenstone belts, rhyolites have been interpreted as products of intracontinental rifting [2,4]. A study of the tectono-stratigraphic relationships, rock associations and chemical characteristics of the particularly well-exposed late Archean rhyolites of the Michipicoten greenstone belt, Ontario (figure 1) suggests that convergent plate margin models are more appropriate.

Three time-equivalent stratigraphic sequences of volcanism (figure 2), each including both mafic and felsic rocks, have been recognized in the Michipicoten greenstone belt [5,6,7,8]. The lower volcanic sequence is most well-preserved and therefore has been studied in most detail. It consists of a largely mafic unit (MV1) conformably overlain by a thick (up to about 700m), mainly felsic volcanic succession (FV1), which was emplaced approximately 2743 Ma ago [9]. In the Michipicoten Harbour area, an undated basal felsic flow unit is structurally discontinuous with the mafic sequence. Along the northern margin of the belt, epiclastic sediments are deposited on apparently older granitoid basement, and are overlain by felsic volcanics (and iron formation) that may be time-correlative with the Michipicoten Harbour felsic flows.



A range of depositional environments apparently existed for the felsic volcanic rocks of the lower volcanic sequence. Subaerial non-welded massive ash flows, shallow water accretionary lapilli-bearing hyalotuffs and deeper water bedded pyroclastic deposits all have been recognized [6,7,10]. Similarly, sedimentary rocks that overlie the lower volcanic sequence were deposited in both subaerial (braided fluvial and alluvial fan) and subaqueous (turbidite) environments [11].

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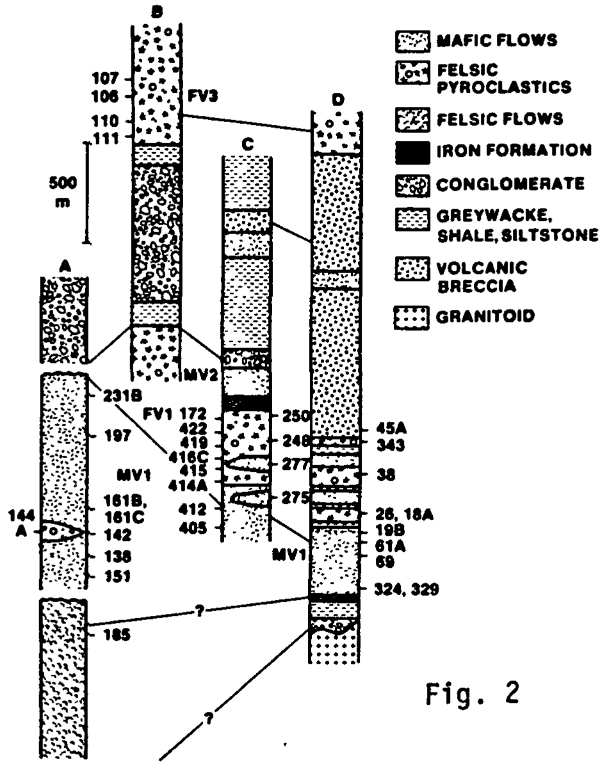

Fig. 2

Voluminous Cenozoic rhyolitic pyroclastic deposits are erupted on continental (rather than oceanic) crust and exhibit distinctive chemical characteristics and rock associations depending on whether that crust was the site of intracontinental rifting or subduction. Three examples of Cenozoic rhyolites associated with intracontinental, extension-related tectonism are presented in Table 1. The Trans-Pecos volcanic province of west Texas represents a rift dominated by alkaline to peralkaline rocks of bimodal basalt-rhyolite composition. The rhyolites are dominated by low-silica (<75wt%) compositions that tend to be depleted in alumina and lime relative to iron and the alkalis. The Rio Grande rift of New Mexico consists of a more continuous spectrum of mafic to felsic compositions that are commonly described as calc-alkaline [14]. Rhyolitic rocks, such as the Bandelier Tuff, are dominated by high-silica compositions. The Yellowstone Plateau volcanic field represents a third extension-related rhyolite group characterized by an association with continental flood basalts and "hot spot" activity. Yellowstone rhyolites are compositionally similar to the subalkaline rhyolites of the Rio Grande rift.

Cenozoic ash flow tuffs of rhyolitic composition also are erupted in voluminous proportions in continental inner arc regions of convergent plate margins. Relative to rhyolites formed in intracontinental rifts or hot spots, inner arc subduction-related rhyolites tend to have higher ratios of alumina and lime to iron and the alkalis (> about 1.4) and a more continuous spectrum of low- to high-silica compositions. Three examples of inner arc Cenozoic rhyolites are listed in Table 2. They differ mainly with respect to whether a field association with voluminous coeval intermediate volcanics is present (San Juan field), ambiguous (Sierra Madre Occidental) or not found

TABLE 1

VOLUMINOUS CENOZOIC RHYOLITIC ASH-FLOW TUFFS

Extension-related, intracontinental suites

	Dominant SiO_2 range	$(Al_2O_3 + CaO)/(FeO_t + alkalis)$	Associated volcanics
1. Trans Pecos Volcanic, Province, Texas [12]	70-75 wt.%	0.76 - 1.25	hawaiite, mugearite, trachyte
2. Bandelier Tuff, Jemez Mountains, New Mexico [13,14]	74 - 77	1.21 - 1.43	basaltic andesite to rhyodacite
3. Yellowstone Plateau Volcanic Field [15]	75 - 77	1.24 - 1.37	olivine tholeiite

TABLE 2

VOLUMINOUS CENOZOIC RHYOLITIC ASH-FLOW TUFFS

Subduction-related, continental inner arc suites

	Dominant SiO_2 range	$(Al_2O_3 + CaO)/(FeO_t + alkalis)$	Associated volcanics
1. Taupo Volcanic Zone, New Zealand [16]	69-77 wt.%	1.57 - 1.71	minor high-Al basalt to dacite
2. Mid-Tertiary Upper Volcanic Sequence, Sierra Madre Occidental, Mexico [17]	70 - 77	1.62 - 1.85	minor basaltic andesite to dacite
3. Oligocene Ash-Flows, San Juan Volcanic Field, Colorado [18]	64 - 76	1.34 - 2.05	voluminous andesite to qtz latite

(Taupo volcanic zone).

If Cenozoic rhyolites may be used as a guide, the Michipicoten lower volcanic sequence (FV1) rhyolites, which are characterized by a continuous spectrum of silica compositions and relatively high ratios of alumina and lime to iron and the alkalis (Table 3), are more likely to be subduction-related than intracontinental rift-related. The Taupo volcanic zone and neighboring Kermadec-Tonga island arc system [19] offer perhaps the most appropriate plate tectonic analogue. At this convergent plate margin, rhyolitic pyroclastic rocks erupted from the New Zealand continental crust actually are deposited largely on the adjacent sea floor [20], which also is the depositional site for tholeiites derived from the Kermadec-Tonga island arc. The resulting ocean floor/continental slope deposits should consist of interfingering rhyolites and basalts derived independently from continental and oceanic platforms, respectively.

TABLE 3

LOWER CYCLE MICHIPICOTEN RHYOLITES (FV1)

	Dominant SiO_2 range	$(Al_2O_3 + CaO)/(FeO_t + alkalis)$	Associated volcanics
Low-silica type	70-73 wt.%	1.69 - 2.44	minor enriched basalt, dacite
High-silica type	74 - 78	1.67 - 2.28	minor enriched basalt, dacite

A similar tectonic-depositional model may explain the so-called cyclical mafic to felsic stratigraphic relationships present in the Michipicoten belt. The presence of pre-existing granitoid crust flanking the belt and the well-known compositional similarity between Cenozoic island arc tholeiites and Archean greenstone belt tholeiites [21], such as those present in the Michipicoten belt [22], support this interpretation. However, the existence of subaerial and shallow subaqueous depositional environments for some Michipicoten volcanic, volcaniclastic and sedimentary units requires either intermittent, local emergence of the volcanic pile or the existence of at least small continental blocks underlying parts of the belt.

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