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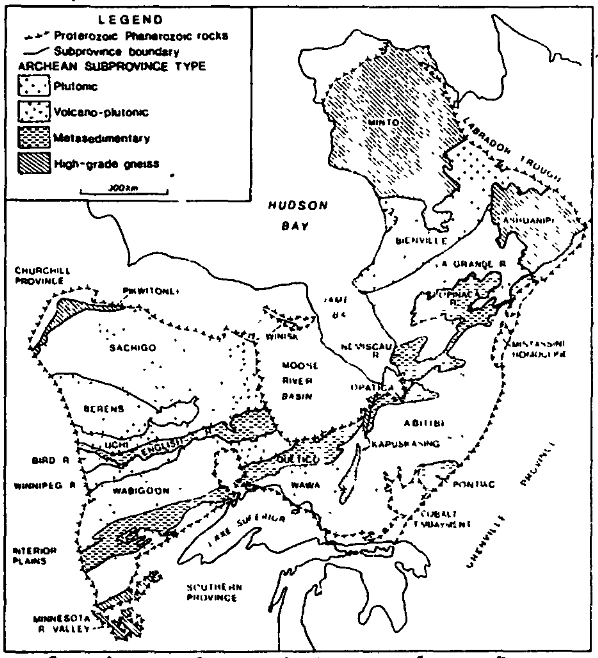
TECTONIC SETTING AND EVOLUTION OF LATE ARCHEAN GREENSTONE BELTS OF SUPERIOR PROVINCE, CANADA: K.D. Card, Geological Survey of Canada

Late Archean (3.0-2.5 Ga) greenstone belts are a major component of the Superior Province of the Canadian Shield where alternating, metavolcanic - rich and metasedimentary - rich subprovinces form a prominent central striped region bordered in part by high-grade gneiss subprovinces, the Pikiwitonei and Minto in the north, and the Minnesota River Valley in the south. The high-grade gneiss subprovinces are characterized by granulite facies gneiss of plutonic and supracrustal origin, and by abundant plutonic rocks. Minnesota River Valley has rocks older than 3.5 Ga; absolute ages of Pikiwitonei and Minto rocks re unknown but Minto does have north-south structural trends distinctive from the dominant east-west structures of Superior Province.

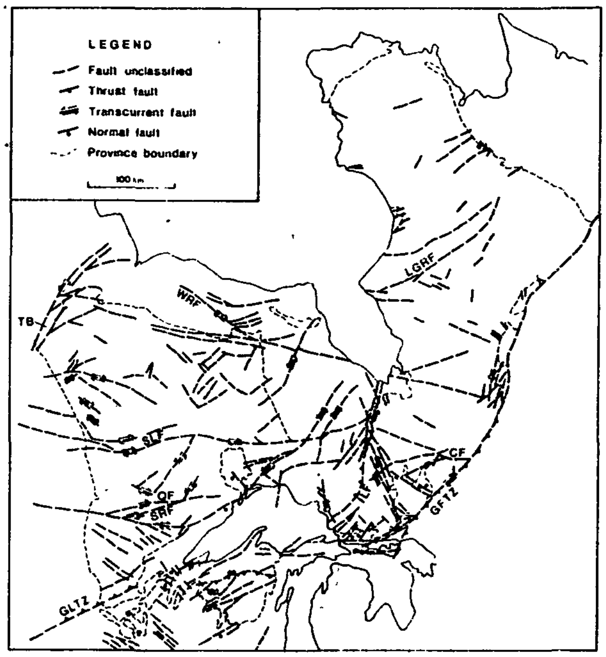


Volcano-plutonic subprovinces of Superior Province consist of generally narrow sinous greenstone belts bordered and intruded by voluminous plutonic rocks, including tonalitic gneiss, synvolcanic plutons, and younger foliated to massive, generally composite plutons, ranging from quartz dorite to granite and syenite. Supracrustal rocks of the greenstone belts include komatiitic, tholeiitic, calc-alkalic, and rare alkalic volcanics with volcanogenic clastic (wacke, conglomerate) and chemical (iron formation, chert) sediments. Most greenstone belts consist of several lensoid, overlapping piles each on the order of 100 km in maximum dimension and approximately 5 to 10 km thick and commonly comprising several volcanic cycles. Some cycles consist of a lower komatiitic -tholeiitic basalt sequence, a middle tholeiitic basalt -andesite sequence, and an upper calc-alkalic dacite-rhyolite-andesite sequence. Other cyles are bimodal tholeiitic basalt-dacite (rhyolite) sequences. Minor alkalic and shoshonitic volcanics and associated alluvial/fluvial sediments are present in some belts where they unconformably overlie older volcanics and synvolcanic plutons. In term of rock types, sequences, and overall configuration, many Superior Province greenstone belts are closely comparable to modern island arcs.

Superior Province greenstone belts typically have upright folds with curved, bifurcating axial surfaces, steep foliations and lineations, and major domal culminations and depressions, the products of polyphase deformation. Some belts, however, display low angle foliations and faults, overturned sequences, and recumbent and downward - facing structures suggestive of thrust-nappe style tectonics (1,9,10).

The enclosing gneissic and plutonic rocks display domal structural patterns, again the product of polyphase deformation involving recumbent folding and diapirism. Metamorphic grade in the greenstone belts is generally subgreenschist to greenschist in the central parts grading outward to low pressure amphibolite facies in belt margins and surrounding plutonic gneisses.

The contacts between greenstone belts and enclosing plutonic rocks, and between the greenstone-rich subprovinces and adjacent plutonic subprovinces are generally either intrusive or tectonic. An unconformity between greenstones and older granitoid rocks has been demonstrated only at Steeprock, Ontario(5) and although younger volcanics and older plutonic rocks are juxtaposed in a number of places, faults, mylonites, or shear zones invariably intervene. Dextral transcurrent faults trending EW and NW and sinistral faults trending NE form subprovince boundaries in part, as do NE and EW trending thrusts. One notable product of this faulting, the Kapuskasing Structural Zone, exposes granulites considered to represent upthrusted lower crust (7,8). Late alkalic volcanic - fluviatile sediment sequences are spatially related to major transcurrent faults and may represent deposition in pull-apart basins formed by alternating periods of transtension and transpression in strike-slip zones.

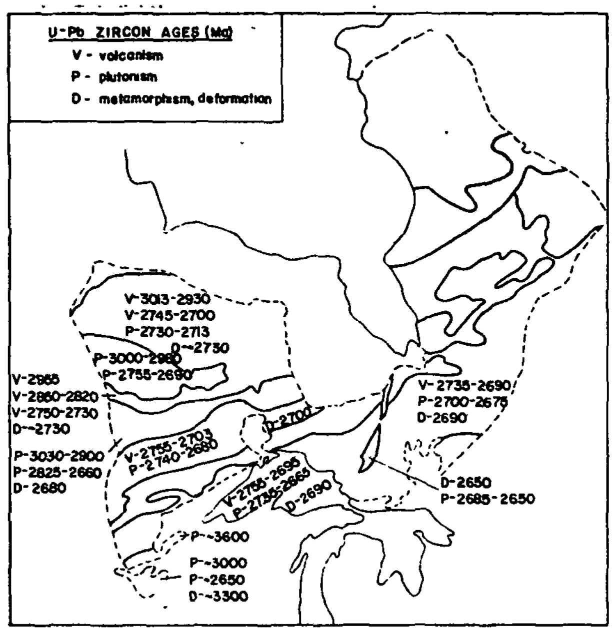


Interpretation of geophysical data shows changes in depth to the Conrad Discontinuity and to the Moho from one subprovince to another, indicating significant structural relief across their faulted boundaries (4). Greenstone belts of Abitibi and Wabigoon subprovinces generally extend to depths of only 5 to 10 km(3) whereas metasedimentary gneisses of English River Subprovince and plutonic rocks of Winnipeg River Subprovince may extend to depths of 10 to 20 km(4). Juxtaposition of high-pressure granulites of the Kapuskasing zone with low-pressure greenschist-amphibolite facies rocks of Abitibi Subprovince implies structural relief of 15 to 20 km across the boundary thrust (7,8).

Metasedimentary subprovinces (English River, Quetico, Pontiac etc.) consist mainly of turbidite wacke and pelite metamorphosed at grades ranging from low greenschist at belt margins to upper amphibolite and locally, low-pressure granulite in belt interiors. Anatectic, s-type granitic rocks are prevalent in the migmatitic, high-grade interiors of the metasedimentary belts.

Most metasedimentary subprovinces have a linear aspect attributable to transcurrent boundary faults and isoclinal folds with subhorizontal to subertical axes, late structures superimposed on earlier complex, recumbent folds and dome-basin structures. In areas where contacts between metasedimentary and volcano-plutonic subprovinces are unfaulted, there appear to be rapid facies transitions from sedimentary to dominantly volcanic sequences. Preliminary isotopic age data also indicate that the sedimentary and volcanic sequences of some adjacent subprovinces are broadly coeval.

U-Pb zircon dates demonstrate that volcanic, plutonic, deformational, and metamorphic events of relatively brief duration affected large parts of Superior Province and that there are detectable differences in ages of these events from one area to another(6). In the northwest (Sachigo, Berens, Uchi subprovinces) major volcanism and accompanying plutonism occurred at about 3.0 to 2.9 Ga, 2.85 to 2.80 Ga, and 2.75 to 2.7 Ga. These voclanic episodes were followed by major deformation, metamorphism, and plutonism about 2.73 to 2.7 Ga. In the south (Wabigoon, Wawa, Abitibi subprovinces) volcanism and plutonism occurred mainly between 2.75 and 2.69 Ga, followed by major deformation, metamorphism, and plutonism at about 2.70 to 2.66 Ga. There is evidence for somewhat younger (2.65 to 2.63 Ga) metamorphic-plutonic events, or of later closure of isotopic systems, in the high-grade rocks of the metasedimentary belts and of the Kapuskasing zone.



In summary, Superior Province consists mainly of Late Archean supracrustal and plutonic rocks with Middle Archean gneisses in the south and possibly in the north. The Late Archean supracrustal sequences are possibly mainly of island-arc and inter-arc affinity, although continental rift zone settings have also been postulated(2). Abundant plutonic rocks include early synvolcanic intrusions and later synorogenic and post-orogenic intrusions derived in part from the mantle and in part from crustal melting caused by thermal blanketing of newly-thickened continental crust combined with high mantle heat flux.

The contemporaneity of magmatic and deformational events along the lengths of the belts, coupled with the structural evidence of major compression and transcurrent faulting, is consistent with a subduction-dominated tectonic regime for assembly of the Superior Province orogen. Successive lateral and vertical accretion of volcanic arcs and related sedimentary accumulations, accompanied and followed by voluminous plutonism, resulted in multi-stage crustal thickening and stabilization of the Superior craton prior to emplacement of mafic dyke swarms and Early Proterozoic marginal rifting.

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