THE TERMINAL ARCHEAN “LOAD” GOLD SETTING

Much has been written on the spatial relation of terminal Archean lode gold deposits to late “structural breaks,” but the geotectonic interpretation of these settings remains enigmatic. Regionally, these breaks track but are not specific to subprovince boundaries, are typically continuous over 100s of km in strike length, locally preserve Timiskaming Series orogenic volcanics and sediments, and are a focus for early porphyry and late lamprophyric dyking. Where breaks migrate through granite-greenstone terrane they follow high strain domains separating back-to-back synclinal successions, and oddly, the preservation of orogenic volcani-sedimentary sequences trace out the missing anticlines. The gold mineralization is episodic, overlapping with early porphyry intrusions but commonly late with quartz veins filling brittle fault/fracture sets. The mineralization is typically classed as mesothermal, forming non-zoned systems extending for kms along strike and down dip.

The geotectonic significance of Archean breaks has remained enigmatic as they show evidence for reactivating pre-existing stratigraphic discontinuities during terminal Archean cratonization -known as the Kenoran Orogenic Event within the well studied Superior Province. The exact cause of the Kenoran Event is still strongly debated, however it shares much in common with younger collisional orogens which have terminated Supercontinental Cycles thoughout younger earth history. Presumably, arc magmatism was terminated by global arc amalgamation over a goid low at 2700 Ma, and thermal blanketing of anomalously hot subarc lithospheric mantle gave rise to the largest granite bloom in earth history. The depositional history within breaks well tracks orogenic evolution from initial arc amalgamation to late unroofing of granite plutons. The rapid switch from arc to orogenic ash tuff volcanism coincides with the initial formation of felsic volcani-tectonic centers (e.g. the 2695 Ma Krist Volcanic Formation and synchronous Quartz Feldspar Porphyry Intrusions in the Porcupine). The earliest polymict conglomerates have primitive porphyry clasts while late conglomerates have plutonic clasts, thus well documenting the unroofing history. That the break-related deposits commonly form sag-synclines overprinted by late shear fabrics indicates that collapse over domical plutonic complexes coincided with various degrees of strike-slip displacement. Late syenitic intrusions (2675 Ma at Kirkland Lake) crosscut ductile foliations but are themselves brittley deformed.

There is evidence for early subvolcanic porphyry-related Au-Cu (Hollinger-McIntyre) and Au-Mo (Hemlo), medial ductile Au-pyrite in green carbonate (Kerr-Addison), and late brittle Au-As-Sb-Te quartz vein systems (Kirkland Main Break). This suggests gold concentrated episodically throughout the 2695- post 2675 Ma Kenoran collapse, the last stage coinciding with terminal brittle strike-slip deformation. This raises the question whether there is a common or disparate modes of genesis. On appearance, there is clearly a spatial tie of gold concentration to early quartz feldspar, and late syenite porphyry centers, suggesting release of magmatic fluids discharged at quite shallow crustal levels. Very old inherited zircon (2.8 Ga at Hemlo) indicates that quartz feldspar porphyry formed by relatively low temperature melting of deep crust, while the mafic and felsic syenites may be linked to lamprophyric mantle magmatism. In detail, however, gold mineralization is sited on structures demonstrating wholesale carbonate alteration coupled with more focused potassic hydrothermal overprints and paragenetically late reduced sulphidization. Such a decoupled C02-K2O-H20-H2S transporting medium is perhaps best accounted for by metamorphic devolitilization of the orogenic infrastructure through break-related brittle-ductile structures.

The polarization of magmatic vs metamorphic fluid agents has long prohibited consensus in the orogenic gold debate. Given there is precious little gold in the crust or mantle (<4ppb) yet local gold camps can have amazing concentrations (Porcupine Camp >60 moz, Kirkland Lake Camp >40 moz), huge volumes of any crust/mantle reservoir must have been efficiently leached, and whatever the transporting agent, it must have been structurally focused into quite local domains of crust. Given this overriding factor, perhaps the most likely scenario is to derive auriferous fluid through prograde metamorphism, and that this fluid migrates to the apex of plutonic-porphyry columns, to give rise to hydrothermal mineralization at various crustal levels. Possibly the close association to high level porphyry centers is best accounted for by porphyry intruding its own hydrothermally plumbed carapace, i.e. porphyry-hosted mineralization is through contamination. This interpretation emphasizes a metamorphic devolatilization process coupled to granite-syenite genesis, thus of necessity one that effectively taps huge areas of crust or even mantle. Devolitilization of gas rich CO2-H20-H2S fluid has been shown to be an effective scavenger of volatile elements commonly associated at gold camps. Linking the gold reservoir to the thermal areoles of granite-syenite complexes (i.e. TAG systems) can well account for the entire spectrum of lode gold deposits as are known in plutonic, porphyry, and epithermal crustal settings.

The best modern tectonic analogue to the Kenoran lode gold setting is demonstrated by the mid-Tertiary collapse of the Laramide Orogen in the western Cordillera. Laramide collision switched off when the East Pacific Rise intersected the trench and subduction switched to transform faulting. The decoupled underplated oceanic crust delaminated east to west, and slab role back initiated voluminous basaltic magmatism in the overlying decompressed mantle. This set the stage for extensional orogenic crustal collapse with coincident regional ash tuff volcanism. The mid-Tertiary lode gold mineralization occurs proximal to rapidly unroofed igneous centers, and again shows a broad range of crustal settings, from deep (5 km) Carlin systems, to medial detachment fault controlled (Mesquite), to surface hot spring deposits (Round Mountain). Perhaps the most important lesson to take from a direct comparison of the Kenoran and Laramide gold provinces is that the gold concentration coincides with very rapid thinning of orogenic crust. In the Kenoran, there is no magmatic gap separating arc and orogenic magmatism as there is in the case of the Laramide, suggesting much more mobile crustal conditions. Arc magmatism ended at 2700 Ma, orogenic collapse occurred between 2695 and 2675 Ma and the Archean crust stabilized within 25 Ma. Separating igneous melt and metamorphic fluid generation may become difficult in rapidly thinned orogenic crust, but certainly rapid decompression favours dryer melts and more voluminous hydrothermal fluid generation. Gold camps clearly demonstrate that both melt and fluid are structurally channeled, the Archean breaks having much the same regional control on upper crustal extension as do detachment faults in the case of the post-Laramide collapse.