

Inferred Deep-Water Eruptive Processes From the Archean Val d'Or Formation, Abitibi Greenstone Belt, Quebec, Canada

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The 3-5 km-thick Val d'Or Formation represents a segment of a subaqueous Archean arc. A deep-marine setting is inferred based on pillowed flows, turbiditic tuffs, an absence of shallow-water, wave-influenced deposits, as well as the stratigraphic position where a komatiitic-basaltic formation underlies and a tholeiitic basalt sequence overlies the arc succession. The VDF features 1-40 m-thick, feldspar- and hornblende-phyric pillowed flows interstratified with 5-40 m-thick volcanoclastic beds. Pillow morphology varies from amoeboidal- to bun-shaped with vesicularity ranging between 5-40%. Fragment shape appears to be a function of size, whereby breccia-size fragments are subrounded and lapilli fragments subangular (vesicularity up to 40%). Volcanoclastic beds are amalgamated units composed of 30-50 cm-thick lapilli tuff, 40-100 cm-thick lapilli tuff breccia and 1-5 m-thick tuff breccia with 5-50 cm-thick subordinate fine- to coarse-grained tuff. Massive to graded tuff breccias have a homogeneous population of vesicular subrounded fragments, some with chilled margins and are typically overlain by another tuff breccia bed with a decrease in the maximum fragment size representing a doubly-graded sequence. These doubly-graded sequences are composed of 3 to >10 individual beds that range from 2-5 m-thick tuff breccias at the base to 30-50 cm-thick tuffs at the top and are occasionally overlain by new graded sequence. The matrix- to clast-supported tuff breccias are analogous to high-density cohesive debris flows. Contacts are gradational to diffuse between breccia-dominated beds, but are sharp to erosive between lapilli tuff and tuff beds. Fine- to coarse-grained tuffs are massive to graded beds that become laminated up section and represent high- (S3 or Ta) to low-concentration (Tbc) turbidity deposits. Local stratified lapilli tuff beds contain internal erosive contacts suggestive of traction carpet processes similar to S1 beds.

The interstratification of vesicular pillowed flows and brecciated deposits of large subrounded vesicular fragments indicate that these volcanoclastic deposits are not pillow breccia, but originate from a probable eruption of volatile-rich magma via a frothy or boil-over type mechanism. Such an eruption is envisaged in a deep-water setting under high hydrostatic pressure whereby explosive fragmentation is not as efficient, resulting in large vesicular fragments. Furthermore, due to their size, larger fragments retain heat better, thereby facilitating plastic deformation into subrounded forms. The decrease in fragment size up section attests to a possible change to more phreatomagmatic lava fountaining, exemplified by a capping 30-50 cm-thick tuff bed

composed of abundant broken euhedral feldspar crystals. A complete sequence forms a 20-30 m-thick amalgamated volcanoclastic deposit of tuff breccia at the base to a capping tuff. The depositional units all indicate transport and emplacement under water-laden conditions, however their homogeneous character and mineralogical and textural similarity to andesitic pillowed flows argues for an eruption-fed origin versus resedimented. Moreover, doubly-graded volcanoclastic beds suggests deposition from a subaqueous explosive eruption by a series of small vertically collapsing columns. A typical depositional sequence is suggestive of a continuum of events from an initial frothy to boil-over eruption or possible lava fountain, in which transport was via water-laden, cohesive debris flows to high- and low-concentration turbidity currents.