Recognition of Precambrian Eruption-Fed Density Currents: the Response to Shallow-Water, Small Volume Eruptions

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Eruption-fed density currents are known to form during small volume Surtseyan-type eruptions that occur in shallow-water settings. The pyroclastic deposits from Kangerluluk Southeast Greenland and the Schakalsberg Mountains, Namibia are basaltic, whereas the Rosh Pinah volcaniclastic rocks in Namibia may represent the felsic counterpart. The bounding facies in all three study areas attest to subaqueous deposition. The 1.8 Ga Kangerluluk deposits, up to 50 m thick, are interstratified with pillowed flows that locally interfinger with a 40 m-thick peperite sequence. The ca. 0.72 Ga Schakalsberg sequence is part of 1 km-thick basalt succession, representing the Adamastor Sea, whereas the 0.74 Ga Rosh Pinah volcaniclastic rocks are an integral part of the shallow-water, turbidite-hosted, 30 million tonne, Rosh Pinah sedimentary-exhalative ore deposit (Sedex).

The mafic and felsic volcaniclastic deposits are 1-30 m-thick units composed of 2-50 cm-thick tuffs and lapilli tuffs, and 5-15 m-thick lapilli tuff breccia units with 10-60 cm-thick tuff beds (restricted to the Kangerluluk sequence). These units are considered the direct products of subaqueous explosions. Paroxysmal shallow-water subaqueous eruptions are inferred based on volcanic textures and structures, volcanic constituents, sedimentary structures and bounding volcano-sedimentary facies. The deposits display bomb sags, and contain wavy- to planar bedforms with normal and inverse to normal grading. They are composed of constituents such as amoeboid pyroclasts with chilled margins, scoria, angular volcanic clasts, euhedral feldspar and hornblende crystals, and local accretionary lapilli. Collectively, these attributes are compelling indicators for explosivity and primary deposition, whereas the enclosing facies indicate subaqueous deposition and imply subaqueous eruption. The graded wavy to planar beds are strikingly similar to base surge deposits and may well constitute some form of subaqueous analogue. The fact that some of these features are observed in felsic rocks suggests that subaqueous eruption-fed deposits are not restricted to basaltic magmas.

In addition to bombs and bomb-sag structures, accretionary lapilli require a gas-water vapour zone that can be accommodated by a steam envelope. In order to create a subaqueous steam envelope, continual magma uprush or expulsion is a prerequisite. Accretionary lapilli formation would necessitate such conditions, rather than short term (seconds) subaqueous tephra jetting. Collapse of the steam envelope due to water ingestion and weakening magma uprush causes the formation of cold-water density currents. The constant interaction between water and vesiculating magma, as well as rapidly changing magma supply conditions, allows for complex volcaniclastic successions in which prominent subaqueous transport processes and deposits are interrupted by those of ephemeral gas-phase, "subaerial-like" environments that form underwater. Only detailed facies analysis and identification of volcanic constituents will help resolve the identification of cold-emplaced but primary pyroclastic deposits. The transition from volcanic eruption mechanisms to sedimentary transport processes in the subaqueous realm remains an enigma, but with careful field and petrographic observations, the duality of such systems can be better explained.