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Origin of Fe-Ni-Cu sulfides in the 1.77Ga mafic dyke from Satkosia area, Singhbhum Craton (eastern India)

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Numerous mafic dykes of ~2.8-1.7Ga age intruded the Archean granitic crust (~3.5-3.3 Ga) in the Singhbhum Craton. The dykes are oriented in four major directions e.g., NE-SW to NNE-SSW, NW-SE to WNW-ESE, N-S, and E-W. This study is based on the ~1.77Ga WNW-ESE trending Pipilia dykes that have been sampled from the Satkosia area in Orissa-state. The dyke samples from Satkosia have augite (~34-51 modal%; Mg# ≈65.7-82.6; $En_{37-48}Fs_{11-17}Wo_{36-41}$), clinoenstatite (~2 modal%; Mg# ≈68.5-78; $En_{63-70}Fs_{20-29}Wo_{4-5}$), and plagioclase (~35-40 modal%; $An_{11-39}Ab_{44-82}Or_{1-7}$), and show cumulate texture at the central part and intergranular texture at the marginal part. The doleritic rocks are also characterized by the occurrence of granophyric texture (~1-9 modal%). Accessory minerals are Fe-Ti-oxides (~5 modal%), and are titanomagnetite (FeO ≈34.38-39.50 wt%, Fe_2O_3 ≈48.26-56.21 wt%, TiO_2 ≈5.05-9.60 wt%), ilmenite (FeO ≈40.75-43.79 wt%, Fe_2O_3 ≈3.54-10.03 wt%, TiO_2 ≈47.82-50.87 wt%) and sulfides (<1 modal%). Sulfide minerals are disseminated throughout the dyke at Satkosia, and occur along the interstices of silicate and oxide minerals. Sulfide mineral assemblage contains pyrite ± chalcopyrite ± vaesite. Pyrite has Ni ≈ 0.02-1.95 wt% and Co ≈ 0.01-5.70 wt%, and shows weak negative correlation with Fe. Coexisting chalcopyrite has Ni ≈ 0.07-0.30 wt% and Co ≈ 0.02-0.08 wt%. Vaesite contains Ni ≈ 26.40-47.88 wt%, Co ≈ 2.42-10.44 wt%, Fe ≈ 5.54-26.55 wt%, and S ≈ 41.58-46.67 wt%, and plots below the actual field of vaesite in the Fe-Ni-S ternary diagram. Two-pyroxene thermometry yield a temperature range of 1065-978°C and coexisting titanomagnetite-ilmenite reveals equilibration temperature of 731°C-573°C with corresponding fO_2 at NNO+0.3 to FMQ-1.03. The primary magmatic sulfide liquid segregated from the tholeiitic basaltic magma due to decrease in FeO activity after the crystallization of magnetite. The immiscible sulfide liquid was relatively S-rich and evolved along the S-rich portion of the Fe-Ni-S system and initially crystallized mono-sulfide solid solution from which pyrite and vaesite were exsolved during subsolidus cooling below 700 °C. Globally ~1.77-1.79Ga dykes and related LIPs are known to host Ni-Cu sulfide deposits, and the first reported occurrence of sulfides in the ~1.77Ga Singhbhum dyke increases the exploration potentiality of the mafic rocks of this age in the craton.