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Combined 40Ar/39Ar and Fission-Track study of the Freetown Layered Igneous Complex, Freetown, Sierra Leone, West Africa: Implications for the Initial Break-up of Pangea to form the Central Atlantic Ocean and Insight into the Post-rift Evolution of the Sierra Leone Passive Margin

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Sierra Leone lies within the south-western part of the West African Craton and comprises two major Archaean structural divisions: a low-grade granite-greenstone terrane characterised by N-S striking structures and a NW-SE striking highly metamorphosed belt of strained rocks that form the coastal margin of the craton. Intruded into the belt is the Freetown Layered Igneous Complex (FLIC), a tholeiitic magamtic body emplaced prior to or during the break-up of Pangea to form the Central Atlantic Ocean and, forming today the high ground of the coastal outline of Sierra Leone which is one of the most distinctive features on the West African coast.

The break-up of Pangaea to form the Central Atlantic and its passive margins began in the Early Jurassic. Geo-tectonically, the break-up was particularly characterised by the formation of the Central Atlantic Magmatic Province (CAMP), covering once-contiguous parts of North America, Europe, Africa and South America. The FLIC forming part of the heart of CAMP is the largest single layered igneous intrusive yet known on either side of the Central Atlantic, measuring on surface, 65 x 14 x 7 km. Geophysical investigations indicate that the intrusion extends offshore to a depth of about 20 km. Geologically the Complex is a rhythmically layered elongated ultramafic-mafic lopolith divisible into 4 major zones each comprising repeated sequences of troctolitic, gabbroic and anorthositic rocks. An idealised unit of layering is from base upwards: dunite, troctolite, olivine-gabbro, leuco-gabbro, gabbro-norite and anorthosite cumulates.

40Ar-39Ar age spectra and 40Ar/36Ar versus 39Ar/36Ar isochron plots obtained by stepwise-heating experiments on plagioclases, biotites and amphiboles from troctolites, olivine-gabbros, gabbro-norites and anorthosites of the four zones yield plateau and isochron ages that seem to depict the cooling history of the Complex after emplacement. The biotites and some of the plagioclases and amphiboles give very good plateaus that range from 196.3 $\pm$ 3 Ma to 232.1 $\pm$ 9 Ma with the best-fit isochron plots showing a range from 193.3$\pm$ 10 Ma to 234.1 $\pm$ 11 Ma. Because these dates represent cooling ages, we interpret them as representing a minimum intrusion-age of the Complex implying that its true emplacement age might be somewhat older than 230 Ma. Given that most established CAMP ages revolve around 200 Ma or younger, we hypothesise that FLIC represents a hitherto unknown pre-CAMP magmatic event that might have thermally triggered the initial break-up of Pangaea to form the Central Atlantic. This view is consistent with field-observations that the Complex is cross-cut by predominantly coast-parallel mafic dykes attributed to the CAMP dyke-swarm. To ascertain the hypothesis, we are currently carrying out U-Pb zircon dating to establish, precisely, the true emplacement age of the Complex.

The Fission-track ages vary from 91.7 $\pm$ 7 Ma to 114.6 $\pm$ 9 Ma. This age range shows that after emplacement and crystallisation, the FLIC underwent an extremely slow cooling for a long period of time. This in turn implies that after the break-up of Pangea to form, in part, the Sierra Leone margin, a late and slow uplift (Erosion/denudation) that took place during the Cretaceous was a very important geological process that characterised the post-rift evolution of the margin.

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