

DUCTILE SHEARING AND REMOBILIZATION OF PORPHYRITIC GRANITE IN KORO-EGBE AREA, SOUTHWESTERN NIGERIA.

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Abstract

Penetrative metamorphic tectonite fabrics, folds, and shear zones constitute the main structural elements in Koro-Egbe area. Results of field mapping, which was used to constrain the shear zone, revealed the nature of the fabrics in the grey gneiss, schist, meta-basites and the Pan African granites in the area. The development of penetrative fabrics in the large-scale sheeted rocks defines the first deformation episode, D₁. The second deformation episode D₂, is revealed in the horizontal asymmetric folds (Koro-Egbe folds), while a major shear-zone developed during a post-folding phase defines the D₃ event.

Within the shear-zone, bodies of porphyritic biotite granite of Pan African age (600±150Ma) were strongly tectonised with a north-easterly steeply-dipping foliation. Outside the shear zone, the porphyritic granite is relatively undeformed, preserving strong igneous textures. Smaller bodies of fine-medium grained biotite granite occur within the deformed porphyritic bodies in the shearzone. It is considered that the petrogenesis of these smaller bodies is strongly linked with the shearing under a high geothermal condition.

Introduction

Koro-Egbe area falls within the Basement Complex of Southwestern Nigeria. It constitutes part of the western boundary of a major Schist Belt in Nigeria, the Isanlu-Egbe Schist Belt. Although some works have been done in the belt, there is no published work on the structures of the area under consideration. Detailed work on the shear zone is expedient because of its importance in mineral exploration. The Isanlu-Egbe Schist Belt is very important in Nigeria because of its association with many economic minerals. Some of the precious minerals such as gold and silver have strong affinities for shear zones because the latter serve as foci for mineralising fluids.

Minerals like columbite, gold, tourmaline, tantalite, beryl, etc., occur in the area, thus making the area prolific in terms of economic minerals. Reconnaissance stream sediment survey (Bamigboye and Adekeye, 2011), soil survey (Omorinoye and Adekeye, 2013) and wild cat panning were carried out in the area. These yielded promising values for alluvial gold in a few streams within and adjacent to the study area. Further works on detailed mineral prospecting of the area, based on petrography and structural characteristics may, therefore, be necessary.

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Geology

The geology (Fig.1) comprises banded grey gneiss, biotite schist, meta-basites, porphyritic biotite-granite, fine-medium grained granite, sheets and dykes of pegmatite and quartz veins. Brief descriptions of these rocks are given below.

Banded Grey Gneiss

This rock is the major unit in the mapped area. It extends westerly and forms part of the banded grey gneiss in Eruku area (Adekeye and Adedoyin, 2007). The rock is dark grey with well-defined planar fabric that is enhanced by the metamorphic segregation of mafic and felsic minerals. It is variously migmatized with the migmatization more pronounced in the northern part relative to the south. The mineralogical assemblage comprises biotite, quartz, hornblende, microcline and oligoclase. Garnet and sphene occur as accessory minerals.

Biotite Schist

Biotite schist occurs mainly in the eastern part of the area. It occurs as rafts overlying the grey gneiss or sometimes in-folded in to the gneiss. Lenticular and sheet-like exposures were also found interleaved with the amphibolites. The rock exhibits planar fabric, which is concordant with that of the underlying gneiss. It is often invaded by several quartz veins, which occur mainly as sheets. Gold mineralization is sporadically associated with some of the veins. The mineral contents are biotite, microcline, plagioclase, sillimanite, cordierite, quartz, garnet and sphene.

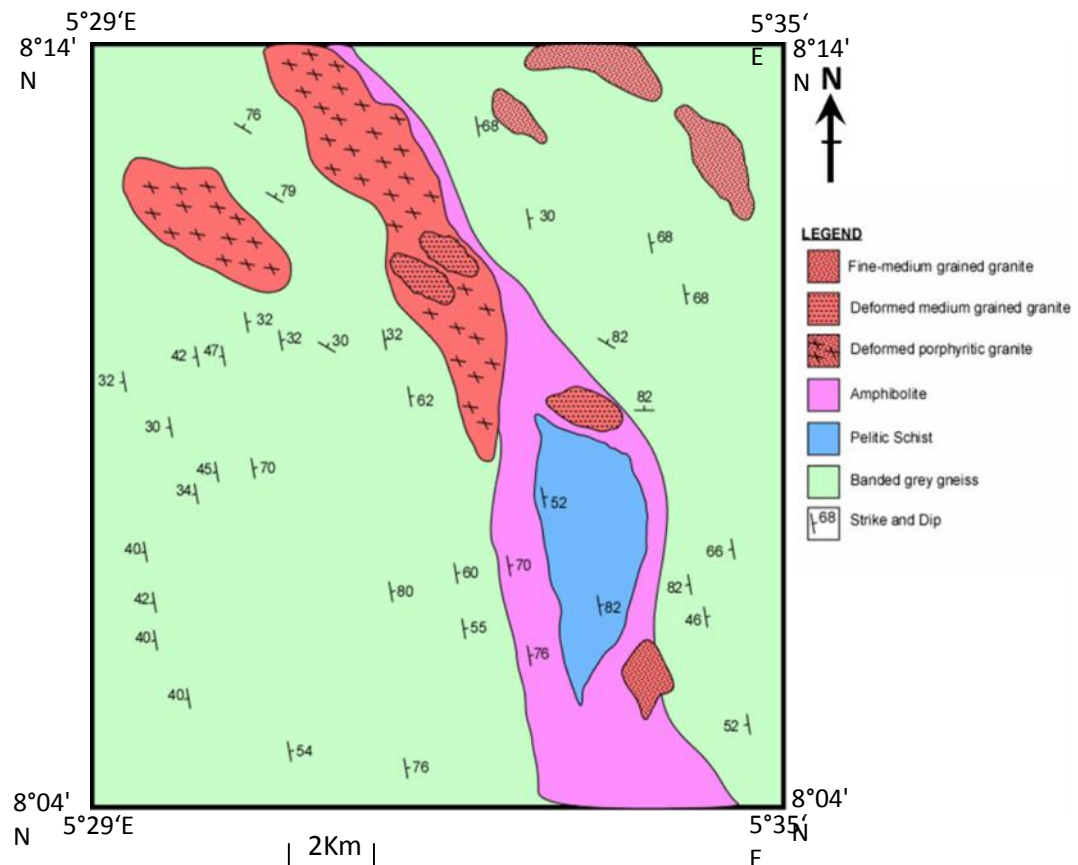


Fig. 1: Geological map of Koro-Egbe and its Environs.

Amphibolites

Foliated and massive amphibolites occur abundantly in the area. They are, sometimes, either inter-banded with, or occur as narrow bands within the schist. They occur dominantly as N-S trending belt which curves north-westerly. The foliated variety is greenish in colour with distinct foliations and a fine- medium grained texture. The massive variety is dark-grey to black, massive and medium-grained. The main minerals include hornblende, plagioclase, quartz, and biotite. Accessory minerals are garnet, zoisite and opaque. Quartz content is high (25-35%), thus making the rock siliceous. This might be as a result of introduction of silica during migmatization.

Porphyritic Granite

The porphyritic granite defines the high topography of the area. It occurs as individual sub-rounded hills or a chain of hills, especially in the central area. A few of the bodies are foliated while most of them are not. The foliated variety is constrained to the shear zone and demonstrates strongly tectonized phenocrysts of microcline and lineated biotite crystals. Microcline, plagioclase, biotite, and accessory sphene constitute the mineralogical assemblage.

Fine-Medium Grained Granite

This variety of granite differs from the former in texture, mineralogy and spatial distribution. It is medium grained, hornblende- bearing and smaller in extent. The rock is exposed mainly east of the porphyritic granite bodies as relatively smaller bodies. The minerals in the rock are quartz, microcline, plagioclase, biotite, hornblende and opaque minerals. Smaller, closely-spaced bodies of medium-grained hornblende-biotite granite occur within the deformed porphyritic granite in the shear zone. The bodies are strongly tectonized, exhibiting elongation of the feldspar, biotite and hornblende.

Discussion

A major shear zone was identified in Koro- Egbe area during the course of this study using structural evidences. Several criteria could be used to identify zones of ductile shearing (Davidson, 1984a, 1984b, Annor and Freeth, 1985). Occurrence of large-scale shear zone is not peculiar to Koro- Egbe area. It occurs in other parts of the world, e.g. the Proterozoic crust of the Musoka, Parry Sand Region of Central Ontario (Schwerdtner and Waddington, 1978) and Southwestern Grenville province of the Canadian shield (Davidson, 1984b), the Rambler shear zone of Wyoming craton (Duebendorfer and Houston, 1987). Major synforms, which are akin to interpretation as shear zones within the Basement Complex of Nigeria have also been reported by various workers e.g. the Igarra pinched asymmetric synform with attenuated short limb (Annor and Freeth, 1985) and the pinched synform of Oke-Ode area, southwestern Nigeria (Adedoyin, et al., 2013). The interest in the study of this shear zone is hinged on its affinity for precious metals.

On the geological map structural traces of strike and lineation directions were abruptly truncated (at least deflected) at the shear zone contacts. On the field, as well as on the geological map, the zone appears as a narrow belt of highly strained rocks in which the bodies of porphyritic granite in the zone are foliated relative to those outside the zone. The zone, which displays a sinistral sense of displacement, bifurcates and then coalesces, having enclosed a smaller lozenge- shaped zone which is undeformed relative to the shear zone. This enclosed portion of the basement occurs about 500m from the eastern border of the shear zone. The enclosed portion has definitely evaded the ductile shearing thus preserving the pre-existing fabric of the sheared basement. This assisted in deducing the age relationships of the various fabrics now exposed in Koro-Egbe area. The shear zone is well developed with distinct structural trends and sharp boundary definitions. The general trend of the shear zone is NW-SE. Occurrence of major shear zones, pinched synforms and fractures are of interest in mineral exploration because they act as good foci for mineralising fluids which yield economic mineral development (Cox et al, 1991, 1995; Groves et al, 2000; Garba, 2002; Adekeye et al, 2012).

From structural data, at least three phases of deformation were established. The first (D_1) is the penetrative planar fabric. This is well developed in the gneisses and the meta-volcano-sedimentary rocks. The second is the fold-forming deformation which resulted in the Koro - Egbe folds. These folds comprise the horizontal asymmetric antiform and the complimentary synform whose northern ends have been obviously deflected westwards by the shear deformation. The antiform is open while the synform is apparently pinched. The mechanism of deformation is being worked on. On the field, and from the map, the fabrics of the shear zone truncate the folds. This implies that shearing postdates D_2 event. It, therefore, belongs to the D_3 tectono-thermal event. Preservation of pre-existing fabric in the

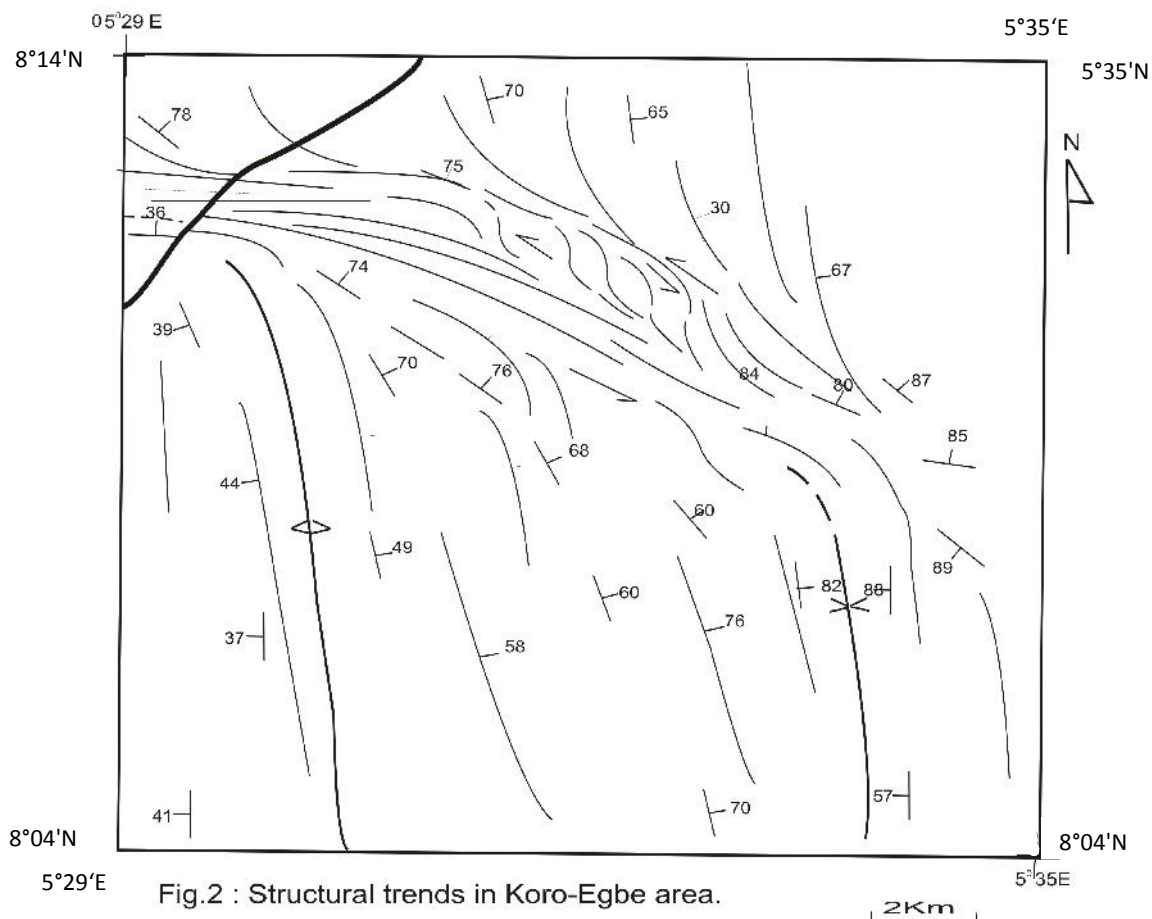


Fig.2 : Structural trends in Koro-Egbe area.

lozenge-shaped structure within the shear zone also gives insight to the deferring timings of deformation. The lozenge preserves the original D_1 fabric and is relatively unaffected by the shearing. That the lozenge-shaped material evaded ductile shearing is interesting but yet to be resolved. The reason for the phenomenon is given to further detailed structural and geochemical analyses. Mafic dykes in form of amphibolites are widespread and they could be used to determine the possible interplay between large-scale shearing and folding because the dykes have registered the finite strain increment of the Koro-Egbe deformation.

West of the mapped area, there are evidences of fold interference culminating in F_2 folds (Adedoyin and Adekeye, 2010). This implies that at least two phases of folding affected the rocks in the area. Phase one involved widespread isoclinal to recumbent folds which are well preserved in the gneisses as minor folds. This phase was followed by upright, virtually penetrative refolding in the metamorphic rocks. Going by this submission, up to four episodes of localized deformation (D_1 - D_4) might have been registered by the rocks of the area. The contact relationship between the deformed porphyritic granite in the shear zone and the enclosed medium grained granite is gradational. This contact relationship strongly supports the fact that the latter evolved from the former. Strong mineral elongation lineation, parallel to the sense of shearing also suggests that the medium grained granite is syn-deformational. Previous studies have shown that the geothermal gradient in the area was high enough to support such phenomenon (Adedoyin and Adekeye, 2010). The coincidence of the trends of the fine-grained granite with the NNW - SSE direction of the shear zone also strengthens the claim about its origin. The deformation of the granites also occurred during the period of shearing.

Mechanical energy generated during thrusting and shearing could be converted to heat. Tuttle and Bowen, 1958 (in McConell, 1969) have suggested that shear stress along slip planes may generate heat as high as 700°C to 800°C within the shear zones. This temperature is considered adequate for

differential fusion of granitic magma. McConnell (1969) agreed that the temperature is high enough to set off granitization even in a shield area of low geothermal gradient.

Conclusion

The study area witnessed polyphase ductile deformation which was later truncated by the shear zone. The zone is marked by zone-parallel, steeply dipping foliation and mineral elongation lineation. A sinistral sense of shear is preserved by strike-slip, L-S tectonite. Apparently, the porphyritic granite was remobilized during the shearing giving rise to smaller granitic bodies.

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