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Sutures, Dyke Swarms and Carbonatites in People's Democratic Republic of Yemen

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ABSTRACT. The basement rocks in the Lowder-Mudiah area of the Abyan Governorate, P.D.R.Y. (South Yemen) consist of three major lithological units. These are, *viz.*, granitic gneisses, metavolcanics and dyke swarms, with their granite diorite and gabbro host rocks, unconformably and partly covered by Jurassic limestones and Quaternary basalts.

These three lithological units are separated by two main, northeast striking, ductile shear zones, along which sutures are believed to have taken place. Carbonatite dykes intruded through gray granitic gneiss host rock.

Introduction

The Lowder-Mudiah area is situated within the Abyan Governorate of the People's Democratic Republic of Yemen (P.D.R.Y.) (Fig. 1), between longitudes 45°40′ and 46°10′E and latitudes 13°40′and 14°00′N. The area covers approximately 2,200 sq. km and is underlain by a basement of granitic gneiss and a sequence of metavolcanic rocks, regarded by Greenwood and Bleackley (1967) as a part of the Aden Metamorphic Group. These rocks are unconformably overlain by Jurassic limestone (Greenwood and Bleackley 1967) and Quaternary volcanic basalt of the Shugra volcanic field (Cox *et al.* 1977). Elevation in the mapped area varies between 1,100 and 1,200 m, except at the Mukeras Escarpment, where elevations in the mapped area exceed 2,500 m. The escarpment separates the Lowder-Mudiah lowlands from the Mukeras Plateau to the north (Fig. 2).

This paper is part of an ongoing Ph.D. research project by the first author. Mapping is based on aerial photographs at a scale of 1:60,000.

General Geology

The geology of the area is dominated by Precambrian basement rocks, which are unconformably overlain by Jurassic limestone and partly covered by Quaternary basalt flows of the Shugra volcanic field. The basement rocks consist of three major lithological units that are separated by two northeast-striking, ductile-shear thrust zones. The three lithological units are: a) gneissose granites underlying a central belt, b) a sequence of bimodal metavolcanic rocks in the southeast, and c) a weakly altered white granite, diorite and gabbro intruded by mafic to felsic dyke swarms to the northeast. A ductile shear (thrust) zone is located within quartz-biotite gneiss and amphibolites of the central belt. Localized migmatite zones were also found within the same quartz-biotite gneiss and amphibolites.

Sulphide gossans are developed on mineralized quartz veins in the metamorphosed quartz-rhyolite porphyry. Chemical analysis of surface samples reveal that they contain traces of Ag, Pb and Zn.

Pb-Zn mineralization in the form of cavity filling (Karst), associated with barite, is hosted by the Jurassic limestone. It is found in certain pockets outside the border of the mapped area and seems to resemble the Pb-Zn (Mississipi-type) mineralization in the Jurassic (Amran) limestone in Nehim (Jibelah) of North Yemen (Al-Shatory 1989, personal communication).

Structural Geology

Multiple deformation has affected the area and is represented by three recognisable fold episodes, each with its own distinctive style and orientation. Northeast trending isoclinal folds were followed by open folds with vertical axial planes and by northwest trending cross- and kink-folds.

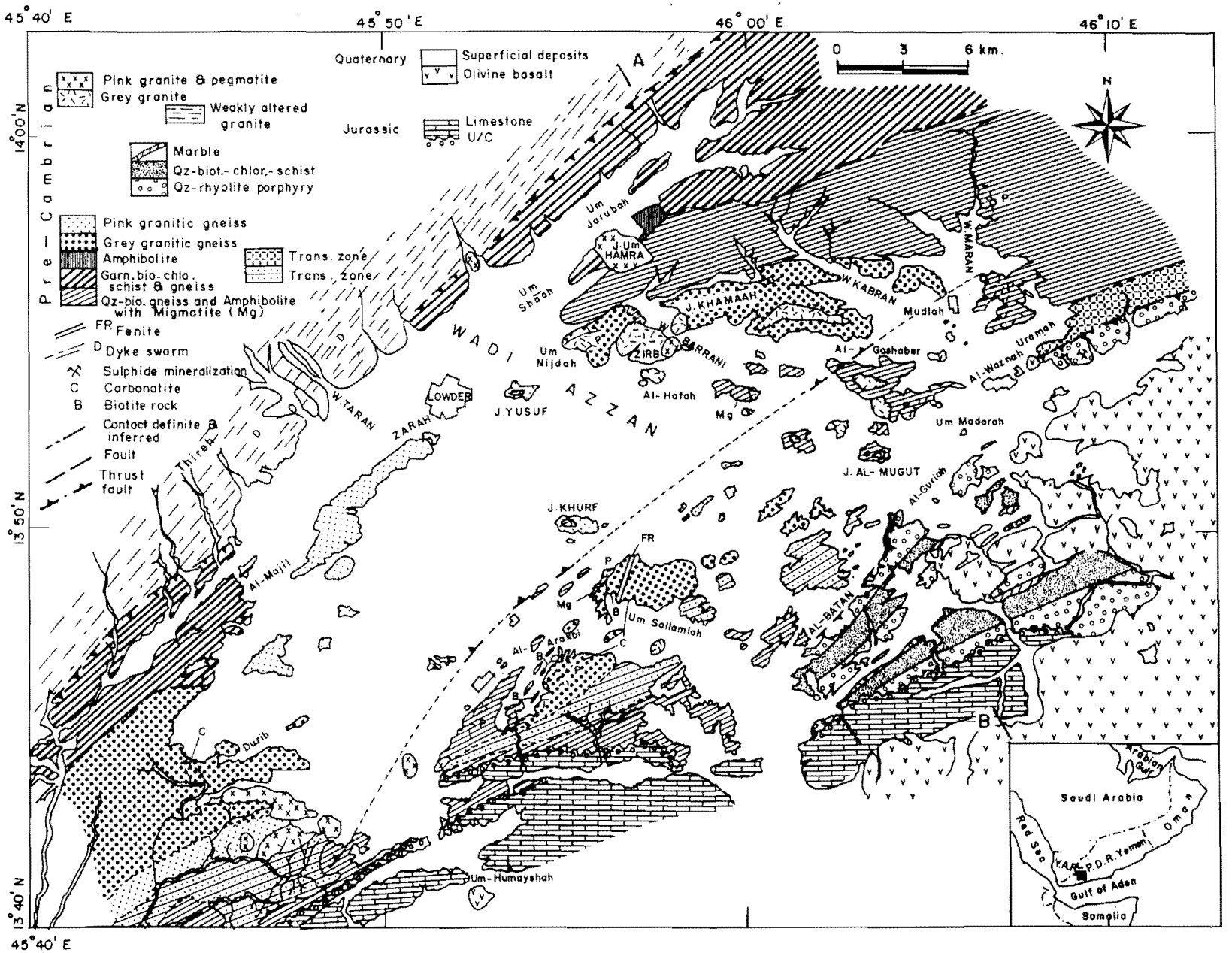

FIG. 1. Geological map of Lowder-Mudiah area (P.D.R. Yemen).

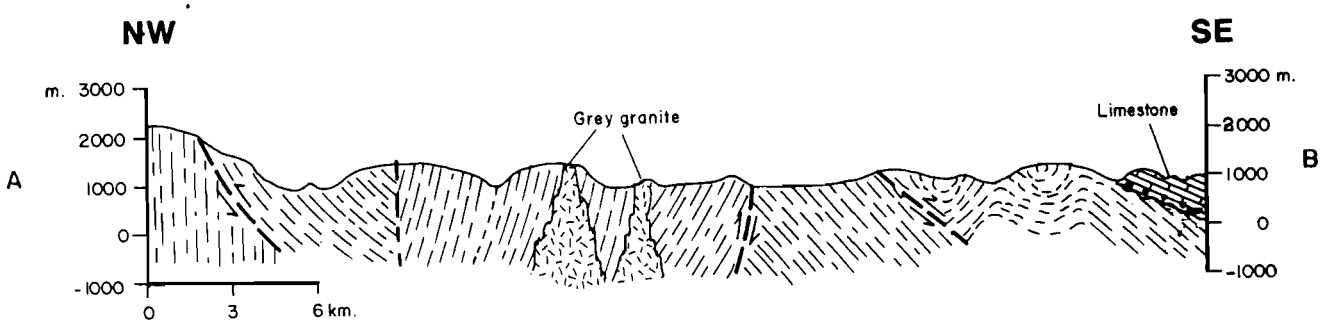

FIG. 2. Structural cross-section along A.B.

Two main ductile shear zones developed on major thrusts, striking northeast. The first zone is located in the eastern part of the area and separates the metavolcanic lithological unit to the east from the granitic gneisses and amphibolites in the central part of the area. The second zone is located in the western margin of the area, separating granitic gneisses and amphibolites from the dyke swarms and their granite, diorite and gabbro host rocks. Shearing along these zones is evidenced by mylonitization, lensoidal fragmentation and sigmoidal textures as characteristic shear fabrics.

A third major shear (thrust?) zone is located within the gneiss belt, marked by sheared quartz-biotite gneiss and amphibolite which have been folded into a northeast plunging antiform. Dislocation is indicated by strong shearing in the quartz-biotite gneisses and amphibolite and their disruption into lens-shaped fragments, and by the interlayering of slices of different rock types. The above assumptions about thrust follow the description by Park (1983).

Sutures

Shackleton (1986) suggested that the dismemberment of ophiolites into lenses and repetition of its units imply the presence of major crustal shear zones. If this suggestion is valid, then the presence of lenses of dismembered, tectonized ophiolite about 100 km southwest of the Lowder-Mudiah area (Al-Derweesh 1988) and along the strike of the ductile shear zone may indicate the presence of a NE-trending suture zone. Another basic-ultrabasic and serpentinized sequence at Mukeras, to the Northwest of Lowder-Mudiah (Dobrenky *et al.* 1977, Saeidan 1989, personal communication) may be indicative of a parallel suture, since it is situated along a major lineament passing through both South and North Yemen.

The proposed sutures seem to be more acceptable if one considers the recent findings of the presence of a suture zone in the horn of Africa and Ethiopia (Windley 1988, personal communication), since the latter region can be regarded as a continuation of South Arabia. Furthermore, similar suture zones parallel to those in South Arabia are under investigation in Madagascar (Windley 1988, personal communication).

Dyke Swarms

The third lithological unit of the basement occupies the western part of the area and forms a northeast trending, 1 km high escarpment that reaches elevations of 2,500 m. The main rock unit is the dyke swarm, which underlies an area of about 20 × 60 km. The dykes are bimodal in composition and intrude rocks which vary from weakly altered white granite to diorite (740 ± 22 Ma) and gabbro. The dikes occupy at least 76% of the total rock volume with an average thickness of 10 m each, and are Precambrian in age since they give K-Ar apparent age of (587 ± 18-709±21 Ma). Trace element analysis show that they have moderate Nb content, and in this and other respects they are similar to intra-continental flood basalts, as also are the basaltic sills within the metavolcanic lithological unit. These rocks may indicate an extensional tectonic environment. The host granitic rock is calc-alkaline, as are the granitic gneisses and the late gray, pink and pegmatite granites; such rocks are likely to be subduction related. Windley and Tarney (1986), discussing the structural evolution of the lower crust in general, stated that exposed basic dyke swarms often represent feeders of lavas within aulacogens under continental forelands. The Mukeras Escarpment dykes may mark a major late Precambrian rifting episode in this segment of the Arabian Shield.

Carbonatite

Carbonatite occurs as dykes intruded into the grey granitic gneiss in the vicinity of Um-Sallamiah, Al-Arakbi and Durib. The dykes are associated with uranium, thorium and potassium anomalies (Abouv *et al.* 1981). Trace and Rare Earth Element analaysis support and confirm field evidence that they are carbonatite, rather than marble.

Conclusion

Although some features of the geology of Lowder-Mudiah are similar to those of the Precambrian of the Arabian Shield in Saudi Arabia (Greenwood *et al.* 1980, Robool *et al.* 1983, and Stoeser *et al.* 1983), there are closer comparisons, in both lithology and structure, with the Precambrian basement of north Somalia (Ba-bttat *et al.* 1990). Thus, there is a possibility that the Yemeni basement is distinct from that of Saudi Arabia and represents a northeastern continuation of the Mozambique Belt, which swings round from north-south to northeast-southwest into southwest Arabia (Warden and Daniels 1983, and Warden and Horkel 1984). A small segment of the Pan-African Shield in Dhofar (Hawkins *et al.* 1981) may also be a part of this belt. The Lowder-Mudiah rocks could represent early Pan-African deep crust thrust up to shallow levels in an island-arc environment. The volcanics of Saudi Arabia (Greenwood *et al.* 1980, Camp 1984, Al-Shanti and Mitchell 1976, Ba-bttat 1978, 1981 and 1985, and Ba-bttat and Hussein 1983) may represent the arc-rock themselves. In other words, the dyke swarms and their granitic host could lie along the southern edge of the Saudi Arabian island-arc belt, while the granitic gneiss of Lowder-Mudiah were thrust up between the Mozambique and Saudi Arabian Terrains.

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دروز التحـام وحشـود جُدَديَّة قاطعـة وصخـور كربـوناتيتيـة في جمهوريـة اليمن الديمقراطيـة الشعبيـة

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المستخلص : تشتمـل منـطقة لودر - مودية من محافظة أبيان بالجمهورية اليمنية على ثلاث وحدات صخرية رئيسـة ، هى : نيس جرانيتي وبـركانيات متحولة وحشد من الجُدَد القاطعة مع صخر مُضيف من الديوريت الجرانيتي والجابرو . يُغطي هذه الوحدات الصخرية جزئيًا ولا توافقيًا حجر جيري جوراسي وبازلت ثلاثي .

يفصل هذه الوحدات الصخرية عن بعضها البعض نطاقا جَزٌّ ، ينحوان باتجاه الشمال الشرقي ، ويُعتقد بأنه قد حدث على طولها درز التحام .

كما تخللت صخور النيس الجرانيتي الرمادية المضيفة جُدَدٌ قاطعةٌ من صخور الكربوناتيت .