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ORIGINAL ARTICLE

Potential for rock-polishing enterprises in southwestern Nigeria

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Abstract Various igneous and metamorphic rocks constitute the basement complex in much of southwestern Nigeria. They are composed of felsic to mafic constitutions, and textural characteristics are wide ranging. Based on petrographic and physical parameters, these rocks hold promise to be utilized for polished items. However, industrial exploitation may be constrained by a number of factors, in some cases by huge financial outlay, environmental pollution and insincerity from government agencies. A sustainable, viable project in ornament stones would demand further geological appraisals, technical facilities, adequate capital and relevant manpower. As in most developing countries, in Nigeria deposits of stones or high-grade geomaterials are commonly blasted indiscriminately, and especially in the southwest, thus there needs to be an awareness and concern for their conservation and environmental protection. Mining of rocks commonly results in environmental degradation; consequently, there is a need to design adequate monitoring and conservation strategies for effective exploitation.

Introduction

The basement complex of Nigeria, which outcrops prominently in the southwest, is composed of a variety of igneous and metamorphic rocks of diverse types and grades that could comprise a dimension stone or polished stone industry.

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Dimension stone in its manifold uses is a ubiquitous material in the industrial world. The desire and necessity to produce non-weathering high quality dimension stones at reasonable cost have increased the search for potentially viable production centers. The longevity and relative importance of centers of stone processing have been and still are largely determined by the quality of the rock formation being mined (Elueze and Olugbenga 2003; Elueze and Ogbe 1988).

Rock polishing has yet to be given appropriate attention in Nigeria, thus allowing for massive importation of finished decorative stones. The need, therefore, for evaluation of the crystalline rocks in Nigeria for local use and export is exceedingly high.

Geological overview and petrological characteristics

The Precambrian terrain of southwestern Nigeria comprises igneous and metamorphic bodies of gneisses, migmatites, pelitic and semi-pelitic schists, psammitic rocks, matebasites, intrusives and associated masses, including older granite ridges and pegmatites. The basement rocks often form well-elevated topographic ridges and inselbergs, especially the gneisses and granites (Elueze 1995).

A number of classification schemes have been proposed for the bodies. However, in this paper, it is considered rather appropriate to adopt an essentially descriptive approach to grouping the following main varieties.

1. Gneisses and migmatites
2. Quartzites and micaceous schist
3. Amphibolites and mafic schist

4. Marble and calc-gneisses
5. Bauchites, syenitic and charnockitic rocks
6. Gabbros, dolerites and lamprophyres

Descriptions of the field and petrographic characteristics of the different rock types are readily available (Oyawoye 1972; Elueze 1992). Textural and compositional attributes are wide ranging. Directional fabrics such as foliation, lineation and lamination often develop in the gneisses, schists, quartzites and tectonized rocks. Granoblastic, porphyroblastic, nematoblastic, lepidoblastic and decussate textures are found in rocks such as quartzites, schists, migmatites, amphibolites and marble.

Physical properties and appraisals

To evaluate the polishing qualities of the rocks, relevant physical variables (Table 1), namely specific gravity, strength, porosity, abrasiveness and aesthetic luster, were determined in representative samples from the basement rocks of southwestern Nigeria. The specific gravity values were found to range from about 2.4 to 2.9, being highest in fine-grained compact mafic varieties, notably dolerites and charnockites. Lower determinations were mainly from micaceous and schistose rocks. Intermediate values were usually typical of the felsic and gneiss assemblages.

Strength discrimination of the rocks based on the point-load tests, using the standard ranking of Deere and Miller (1966) and the modification by Bieniawski (1975) of mean point load strength indices showed that the specimens are of moderate to very high strengths. The melanocratic types are commonly of very high strength (>8.0 Mpa).

Porosity estimations were done as liquid absorption capacities. Water and oil were considered, though the trends in variations are generally similar. Values for water and oil absorption capacities ranged respectively from 0.26 to 0.56% and 0.06 to 0.23%. The lowest percentages were obtained from units of high density and strength. Greater void ratios were found in the less compact samples.

Further scrutiny revealed that strength index, which is notably anisotropic, was the most variable within each rock group. The metamorphic bodies had penetrative preferred orientations like banded gneisses. Laminated quartzites and micaceous schists presented the highest levels of variability. In most cases, the minimum and maximum values were derived from specimens aligned parallel and perpendicular, respectively, to the pervasive directional fabrics. Of the granitic rocks, the porphyritic or porphyroblastic and coarse-grained types usually had lower strength indices and specific gravities.

Abrasiveness and aesthetic luster, as ascertained on polished slabs, likewise portray the differences in petrographic features of the rocks. Wide ranges of commercial products are obtainable as determined in the samples; they generally displayed good abrasiveness, yielding attractive color tints, varying from light to dark, as usually determined by the ratio of felsic to mafic constituents. The more even-textured, finer-grained and darker rocks, such as dolerites, amphibolites, charnockites and syenites, yielded better polished surfaces. The foliated rocks tend to provide tiles and slabs of changeable aesthetic qualities, with alteration in orientation of slicing.

Economic evaluation, environmental and investment potential

The polishable potential of rocks is often based on certain parameters (Table 1), notably, field attributes and relations, petrographic patterns and physical properties. In particular, outcropping style, extent of exposure and degree of petrographic consistency are important indices in economic assessment.

There are many stages involved in rock development. Each of these stages involves different activities and equipment. The major stages in development are exploration, development, mining, abandonment

Table 1 Physical parameters of some of the basement rocks in southwestern, Nigeria (means and ranges)

Rock type	Specific gravity	Standard strength index	Water absorption capacity (%)	Oil absorption capacity (%)
Gneisses and migmatites	2.64 (2.48–2.80)	7.65 (4.30–10.50)	0.39 (0.29–0.51)	0.13 (0.08–0.22)
Quartzites and schists	2.52 (2.42–2.70)	5.49 (3.20–8.80)	0.56 (0.36–0.72)	0.23 (0.17–0.30)
Amphibolites	2.79 (2.73–2.89)	7.16 (5.40–10.07)	0.34 (0.28–0.42)	0.06 (0.05–0.08)
Granites and granodiorites	2.67 (2.53–2.78)	7.13 (3.75–10.85)	0.36 (0.23–0.58)	0.08 (0.06–0.09)
Syenites and charnockites	2.79 (2.62–2.90)	9.38 (7.30–11.77)	0.31 (0.13–0.59)	0.09 (0.08–0.10)
Gabbros and dolerites	2.86 (2.72–2.93)	10.91 (6.75–14.50)	0.26 (0.18–0.32)	0.08 (0.06–0.12)

Table 2 Characterization of polished slabs of some basement rocks in Nigeria (after Elueze 1995)

Rock type	Potential commercial products	Applications and functions
Gneisses and migmatites	Multicolor, diadema, nylandia orieta, vibro verde, spriana, African juparans	Interior and exterior decoration, tiles
Quartzites and schists	Oakley schiefer, favang verde fundres, verde vermion, schiefer brands	Interior and exterior, tiles
Amphibolites and mafic schists	Verde shades, nero tones	Interior and exterior, monunentals
Marbles and calc gneisses	Bianco brands, zebrino, maharani	Interior and exterior, monumental pulpit and altar slabs
Granites, granodiorites and diorites	Grigio, star flash, serizzo verde lights, nero tijucas	Interior and exterior tile, stone items
Syenites and charnockites rocks	Nero ''icheku'', verde-coloured tijucas	Interior and exterior, monumentals, counter, altar tops
Gabbros, dolerites and lamprophyres	Nero oriental, verde, nero assoluto, grunporphyry	Monumentals, tiles, stone items, decoratives

and decommissioning, and transportation. Investment in rock-polishing enterprises in southwestern Nigeria can create job opportunities and contribute to socio-economic and infrastructural developments. Such investment can also bring about technological, capital, management and marketing expertise development and transfer, all with the intention of improving quality of life. However rock-polishing enterprises may have negative consequences, which include human rights violations and environmental degradation that could lead to health problems and destabilization of the entire ecosystem. Having examined the problems experienced by local communities as a result of rock polishing, it is only fair to acknowledge that the investors can suffer huge losses due to organized machinations of other stakeholders against them. In the future, government and the industries should work with local residents as early as possible in the project cycle before the extraction of the rock.

In terms of the physical appraisals of density, strength, porosity and polishing tone, the basement units largely have good prospects to produce a wide range of commercial brands of products (Table 2). However, the restricted exposure and occurrences of veins, veinlets, enclaves, xenoliths, boudins, structural dislocations and weathering effects are obvious limitations to the application of some of the assemblages. For instance, most of the mafic units such as dolerites, gabbros and lamprophyres, which yield high quality polished slabs, are generally not extensive, often being found as dykes or minor bodies. On the other hand, the large charnockitic and syenitic masses, around Ikerre, Osuntedo and Iseyin, as well as the granitic and gneiss rocks of various color tones (reddish, pinkish, grayish, and darkish) around Igbo Ora, Komu, Okeho and north of Ibadan hold better promise for utilization. A number of discrete deposits have been estimated to contain over 10 million tonnes of readily workable materials.

The current indiscriminate blasting and weakening of the outcrops would need to be checked, and further geological investigations and provision of geo-extension services are other prerequisites for developing the envisaged undertakings. As in most mineral-based projects, especially where the raw materials are bulky and non-metallic, factors such as the availability and cost of transportation access, utilities, labor, machinery and market, are likewise relevant to the viability of the enterprises. In particular, the techniques and machines for drilling, jet piercing, splitting, cutting, shaping and polishing of rocks are more specialized, and would require greater investment funds compared to producing stone aggregate. It is therefore advisable to locate the factories for the processing or finishing stages proximate to the working sitesto reduce haulage expenses. In addition, the wastes should be utilized to source aggregates.

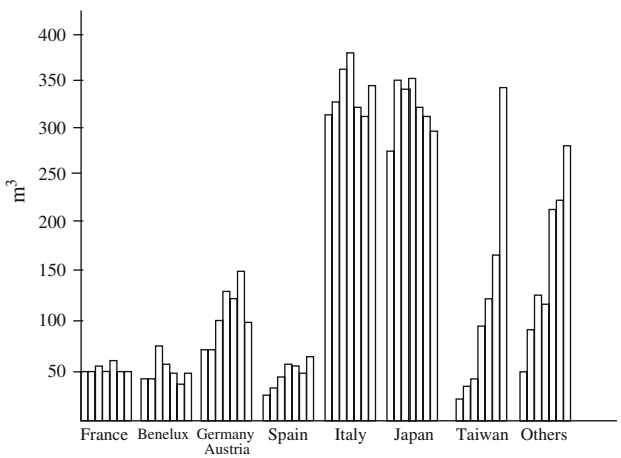

Fig. 1 Raw granite block exports—principal receiving countries

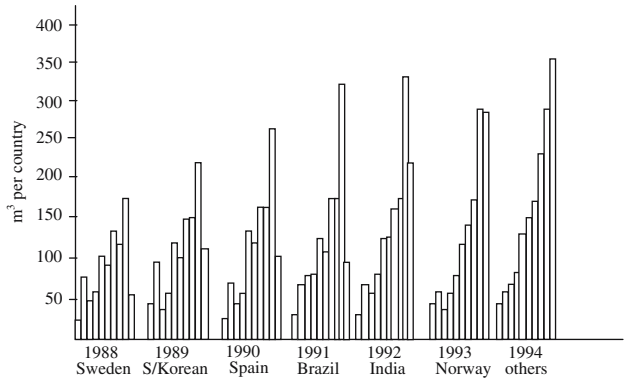

Fig. 2 Raw granite block exports—principal exporting countries

Conclusion

On the whole, the demand for embellished and aesthetic rock products is considerably high in Nigeria and Africa, in general, and prospects for export are quite bright (Elueze 1994). Similarly, market potential for unfinished rock blocks is favourable, especially in countries where greater emphasis is placed on environmental protection and regulation (Figs. 1, 2). A 1-m^3 block can be shipped abroad for cutting, shaping and polishing.

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