

## **Dimension stone of Makawanpur District, central Nepal**

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### **ABSTRACT**

An exploration of polished/dimension stones was carried out in the Makawanpur district. In the study area various rock types were examined for their suitability in terms of quality and strength, and potential areas were delineated for the detailed study. The area is found to comprise various rock types suitable for dimension stones. Among them, the most viable rock types are granite, aplite, marble, limestone, quartzite and amphibolite. This paper describes mineralogy, weathering grade, nature of discontinuities, and physico-mechanical properties of rocks from different potential sites and presents the results of exploration.

### **INTRODUCTION**

The use of polished/dimension stone has been increasing rapidly in Nepal, mainly in the major cities for decorative purposes. Due to rapid urbanisation, the construction of modern buildings and civil structures are increasing day by day and consequently the demand for different decorative stones is also rising up. To fulfill its demand currently, several polished stones like marble, granite and other stone slabs are available in the market. Only a few percentage of the national demand is fulfilled by existing national industries such as Godavari Marble Industry, Everest Marble Industry and other small local slab industries. The rest is fulfilled by import from India and other countries. The various rock types, color, texture, quality, and appearance available in the imported stones have lured the customers to use those imported decorative stones. Tremendous import of such stones from other countries is not only weakening the economy of the country but also is hindering the national industries.

Occurrences of marble, granite, amphibolite, quartzite that may be suitable for polished stone has been reported (UNDP 1981, Stocklin and Bhattarai 1995, Joshi 1971) in the present area of investigation in Makawanpur district. However, no studies have yet been carried out to find out the possibilities of using these stones as polished/dimension stone. Furthermore, these investigation sites are facilitated by electricity and good road networks (Tribhuvan Rajpath, feeder roads to Hetauda Cement Industry, Kulekhani Hydropower Project, Bhimphedi, Chisapanigadhi, Jhurikhet and Namtar). The local people are fairly cultured with mining and other industries. So, in case of the study area becomes feasible for polished/dimension stone industry, the potential markets such as Kathmandu, Hetauda, Birgunj etc. are not far from the project area. In this context, the Department of Mines and Geology has conducted an exploration of polished/dimension stone in 50 km<sup>2</sup> area of Makawanpur district in fiscal year 2001/2002. The main objectives were to

identify the resources of polishing grade rocks, examine for its durability and suitability and prepare a map delineating the important resources in the scale of 1:25000.

### **FIELD INVESTIGATION**

The investigation was carried out within the corridor of 4 to 6 km distances of the existing roads within the area bounded by Sikrikot in the north, Mandu Khola and Okhardanda in the east, Shyauli bazaar and Suparitar in the south and Yanrang village in the west. It covers an area in Survey Dept. Topo-Sheet No. 2785 05C, 2785 09A (Scale 1:25000) with latitude of 27° 27' 00" to 27° 37' 30" N, and longitude of 85° 00' 00" to 85° 07' 30" E. Geological traverses along rivers, roads, and ridges were carried out for examining suitable rock types. Emphasis was given to obtain information on color, appearance, texture and luster of rock types to assess their suitability and intact rock strength and hardness to assess their durability. Rock mass properties were estimated and structural discontinuities were measured. Field studies are supplemented by the laboratory tests and analyses for delineating the possible resources.

### **LABORATORY TEST AND ANALYSIS**

In defining the quality of dimension stone and polished stone, the international organizations such as American Society for Testing Materials (ASTM), European Committee for Standardization and International Standard Organization (ISO) have laid the standards and norms (Osterhuis 1999, Shadmon 1993). In the present study, standardization of ASTM has been used. Accordingly, ASTM defines any natural stone that has been selected, trimmed or cut to specified or indicated shapes or sizes, with or without one or more mechanically dressed surfaces as the "Dimension Stone" (ASTM 1996). When such stones are polished to use in flooring, wall cladding, mausoleum crypt fronts, custom specialties are called polished stone (Barker and



Austin 1994). Its use for different purposes depends upon suitability, durability and color (Power 1994).

As designated in the ASTM standard for the conformation of the suitability and durability of the rock types, the chemical analysis, thin section study and determination of density, absorption by weight, abrasion resistance, and compressive strength were carried out. Rock samples are further polished for checking their appearance and reflectance. The results are compared with the ASTM specifications. Discontinuity analysis was also carried out

to evaluate/estimate possible block sizes that can be obtained while mining.

### RESULTS OF FIELD INVESTIGATION

The study area comprises the rocks of Bhimpheedi Group of Kathmandu Complex and Upper Nawakot Group of Nawakot Complex and Palung granite. Based on the results of investigation, "Polished Stone Exploration Map" of 1:25000

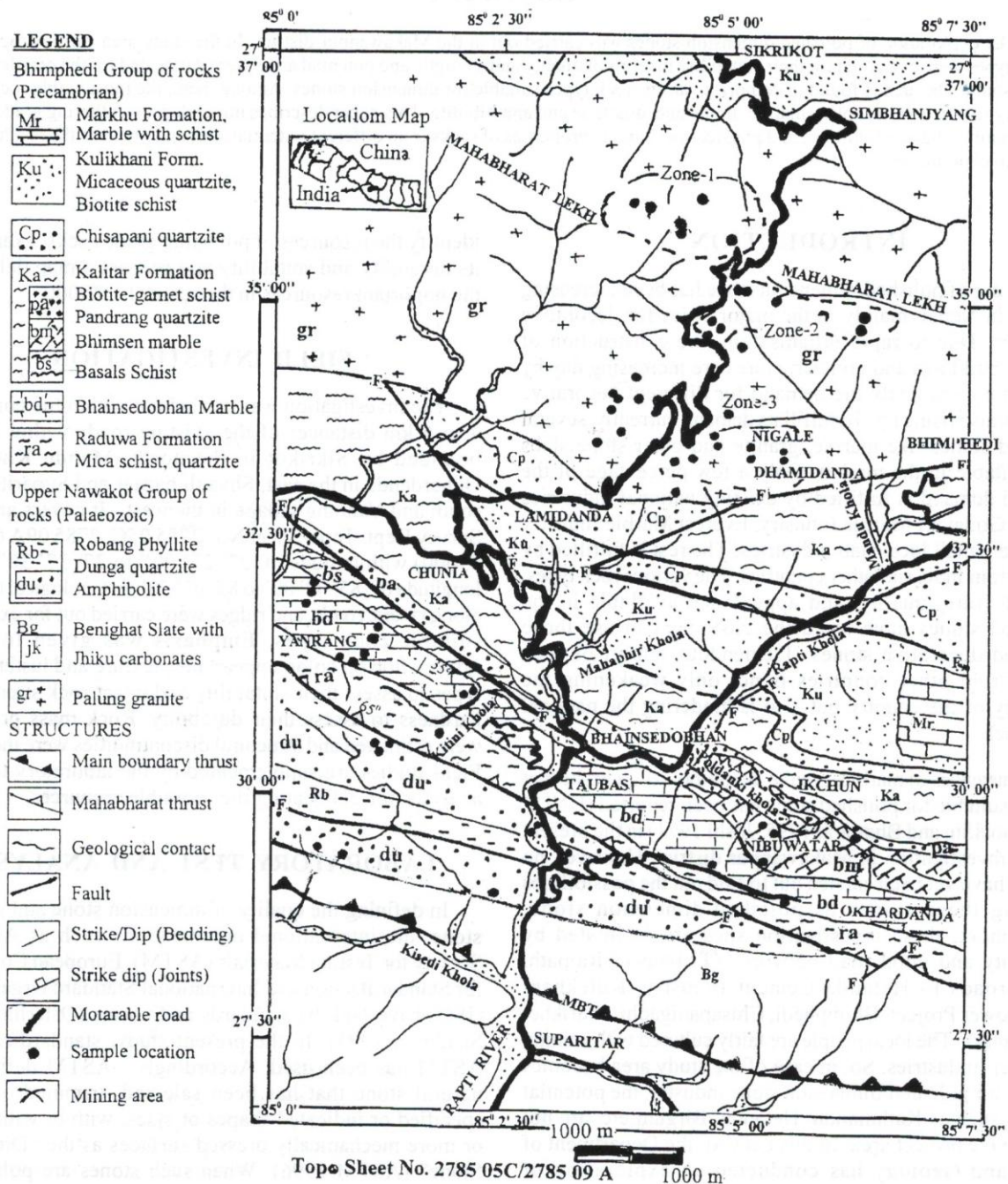


Fig. 1: Polished stone exploration map of parts of Makawanpur District



scale has been prepared (Fig. 1). The important resources found are briefly described below:

**Palung Granite**

Palung Granite is intruded into quartzite, schist and calcareous rocks which is dipping towards north. It comprises of coarse-grained, inequigranular, porphyritic two mica (muscovite and biotite) granite and inequigranular tourmaline granites with irregular veins and lenses of pegmatite and aplitic granite. The fresh coarse grained granite is smoky white to milky white with black to dark unevenly distributed grains of tourmalines or biotites with presence of pyrite at few places. The fine grained aplitic granite with leucocratic texture is also white to milky white colored with presence of evenly distributed dark to black colored fine grained tourmaline and biotite flakes.

The granites on the exposed surface are generally weathered. The weathering profile and strength of the granite are dictated by topographical condition. Slightly weathered to fresh granites are only found suitable for polished stone. Based on estimated intact rock strength, rock mass properties and mining possibilities, granites within the study area are delineated into four specific zones (Fig. 1). Zone-1 and Zone-2 lie nearly 3 km south of Simbhanjyang. Zone -1 represents the granitic cliff in Mahabharat lekh, within half a kilometer west of Tribhuvan Highway. There is no heavy forestation and thick overburden of decomposed granite. It is characterized by three sets of hair tight to open and clay filled joints. Similarly, Zone -2 possesses several exposures of fresh to slightly weathered granite located along the Mahabharat lekh extending towards east of Tribhuvan Highway. However, the ridge is found veneered by residual soil of decomposed granite. Since the slightly weathered granites are found strong enough, several small deposits are good for the present purpose. This granite body is also characterized by three sets of joints. All the joints are with

high persistency. Thus huge blocks of granite could be expected. The discontinuity analysis for Zone-1 and Zone-2 are given in Fig. 2a and 2b, respectively. The details regarding discontinuity characteristics for Rock (ISRM 1978) are given below in Table 1.

Zone-3 covers the area within the ridge of Nigale to Dhamidanda. Fresh to slightly weathered granite along with totally decomposed granite at the ridge show variable weathering profile. Well exposed fresh to slightly weathered granite deposits accessible by Tribhuvan Highway could be of economic value. Rest of the granite within the study area that are either far from the highway or with thick overburden is categorized into Zone-4.

**Marble**

The Bhainsedobhan marble of Bhimpheedi Group of Kathmandu Complex is white and fine to coarse crystalline with layers and lenses of yellow to pinkish and brown possibly dolomitic varieties. The rock seems to be massive, but in close view distinct bedding and fine layers are observed. Such distinct beds in general have thickness of few centimeters to more than one meter. Generally marble beds lying in the central portion are thicker than the beds near the underlying the Raduwa Formation or overlying the Kalitar Formation. The marble beds near the underlying and overlying formations are thinly bedded and steeply dipping towards north. Most of the area covered by the Bhainsedobhan marble falls under the mining licensed area to Hetauda Cement Industry. However, the resources located in the west of Kitini Khola, and the one situated on the north sloping terrain of Bhainse to Okhardanda could be of economic interest.

Marbles found within the Kalitar Formation of Bhimpheedi Group are named as Bhimsen Marbles and comprises of greenish gray, fine to coarse grained marble. Individual

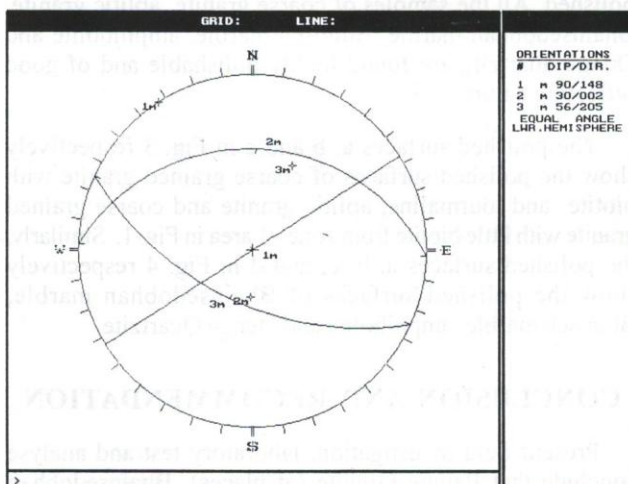


Fig. 2a: Stereographic projection of average attitude of major joints from about 75 joints in Palung granite of Zone-1

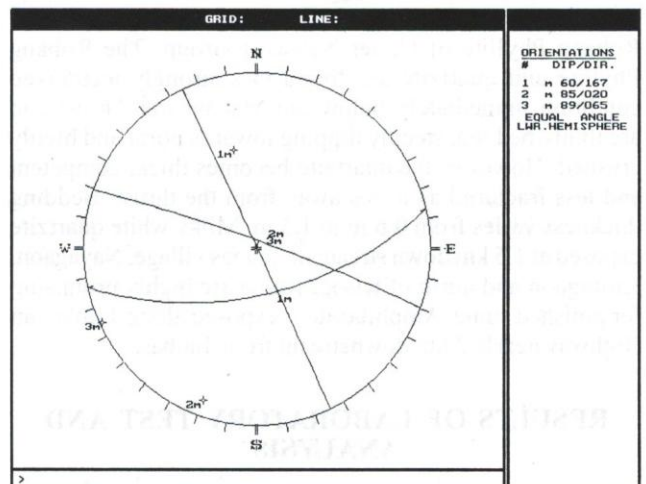


Fig. 2b: Stereographic projection of average attitude of major joints from about 75 joints in Palung granite of Zone-2



**Table 1: Discontinuity characteristics of Zone-1 and Zone-2 of Palung granite**

Location	Zone -1			Zone-2		
	Mahabharat lekh extending west at 0.5 km from Tribhuvan Rajpath, nearly 2 km south of Simbhanjyang			Mahabharat lekh extending east at 0.5 km from Tribhuvan Rajpath, nearly 2.5 km south of Simbhanjyang		
Major joint Sets	J1	J2	J3	J1	J2	J3
Dip/Direction	56°/205°	90°/143°	29°/000°	60°/167°	85°/020°	90°/165°
Spacing (m)	1-1.2	0.6-3	0.8-1.5	0.6-1.6	1.2-3	1.2-1.5
Wall Surface	Planer	Rough Planer	Rough Planar	Rough Planar	Smooth	Smooth Planar
Wall Strength	Medium	Medium - Strong	Medium - Strong	Weak - Medium	Medium	Medium - Strong
Weathering Grade	Moderately	Slightly - Moderately	Slightly	Moderately - Slightly	Moderately - Slightly	Slightly
Overburden to Slightly to Fresh granite	Within few meters			Veneered by completely decomposed granite with exception of some slightly weathered granite exposures.		
Possible Block size in mining	Probably columnar blocks of lateral dimension of 3 m.			Probably conical blocks with possible lateral dimension of 3 m.		

marble bands are from few centimeters to more than 2 m thick and well exposed in the Nibuwtar and Ikchun villages. Bhimsen Marble exposed in Poladanki Khola near Ikchun village comprises of thick beds and is in contact with dark gray micaceous quartzite. This deposit is devoid of overburden except the highly weathered marble. It has attitude of 023°/75°. It is strongly crystallised, and has good appearance and colour. The marble occurring at Chilaune, Nibuwtar and Paribas villages are also thickly bedded.

**Quartzite and Amphibolite**

Dunga Quartzite and amphibolite are associated with the Robang Phyllite of Upper Nawakot Group. The Robang Phyllite and quartzite are found in a strongly tectonized condition immediately below the Mahabharat Thrust and are thinly bedded, steeply dipping towards north and highly crushed. However, the quartzite becomes thick, competent and less fractured as it lies away from the thrust. Bedding thickness varies from 0.6 m to 1.3 m. Milky white quartzite exposed at 1.5 km down stream of Taubas village, Nayagaon, Kitinigaon and north of Kisedi Khola are highly promising for polished stone. Amphibolite is exposed along Tribhuvan Highway nearly 2 km downstream from Taubas.

**RESULTS OF LABORATORY TEST AND ANALYSIS**

The study of two to three thin sections of granite, aplite, amphibolite and marble is carried out and their petrographical descriptions are given in Table 2.

Nine samples of marble, quartzite are analysed for chemical analysis and the results are given in Table 3.

The different tests required for durability of dimension stone as specified by ASTM 1996 are carried out in three to ten samples of different rock types and the results are compared with the ASTM specifications. They are given in Table 4.

The cores of the rock samples of granite, marble, quartzite and amphibolite are cut into thin (10 to 15 mm) circular slices (54 mm in diameter). They are grinded and polished. All the samples of coarse granite, aplitic granite, Bhainsedobhan marble, Bhimsen marble, amphibolite and Dunga quartzite are found highly polishable and of good reflecting nature.

The polished surfaces a, b and c in Fig. 3 respectively show the polished surfaces of coarse grained granite with biotite and tourmaline, aplitic granite and coarse grained granite with little biotite from zone -1 area in Fig. 1. Similarly, the polished surfaces a, b, c, and d in Fig. 4 respectively show the polished surfaces of Bhainsedobhan marble, Bhimsen marble, amphibolite and Dunga Quartzite.

**CONCLUSION AND RECOMMENDATION**

Present field investigation, laboratory test and analyse conclude that Palung Granite (at places), Bhainsedobhan Marble, Bhimsen Marble, Dunga Quartzite and amphibolite from the study area are suitable for polished/dimension stone from both the durability and suitability aspects.



**Table 2: Results of different rocks in thin section**

Rock Type	Color	Texture	Mineralogical Constitutions (%)						
			Quartz	Ortho- clase	Biotite/ Muscovite	Hornblende	Pyro- xene	Calcite	Fe – Oxide
Coarse Granite	Smoky white to milky white with irregular black spots	Inequigranular, porphyritic, fine to medium grained (0.1 –2.1 mm), phenocrysts of quartz and orthoclase	50 to 55	35 to 40	5 to 7	-	-	-	< 1
Aplitic Granite	Light with regular black flakes	Fine grained (0.1 – 0.5) mm	45 to 50	45 to 48	1 to 2	-	-	-	-
Bhainse. marble	White	Fine grained (0.1-0.5 mm), weak planar foliation	3 to 5	-	<0.5	-	-	92 to 95	<1
Bhimsen marble	Bluish gray	Fine to coarse grained (0.1-1.2 mm), granoblastic	5 to 7	-	<0.5	-	-	91 to 93	<0.5
Amphibolite	Gree to dark green	Fine grained, 0.1- 0.5 mm	-	-	-	90 to 92	3 to 5	3	1 to 2

**Table 3: Result of chemical analysis of different rocks**

Rock Type	Sample No.	LOI %	SiO <sub>2</sub> %	R <sub>2</sub> O <sub>3</sub> %	Fe <sub>2</sub> O <sub>3</sub> %	Al <sub>2</sub> O <sub>3</sub> %	CaO %	MgO %
Bhainsedobhan Marble	L4-S3	33.99	16.86	5.32	0.50	4.82	40.65	2.52
	L5-S2	40.65	5.02	3.72	0.55	3.17	46.82	3.72
	L9-S2	42.43	2.68	2.96	0.47	2.49	46.82	5.04
Bhimsen Marble	L28-S1	40.18	5.99	3.58	0.79	2.79	48.22	2.01
	L29-S1	34.33	17.15	4.74	0.90	3.84	42.20	1.20
	L29-S2	36.30	13.31	5.14	0.90	4.24	43.18	1.91
Dunga Quartzite	L14-S2	6.64	77.68	6.62	0.62	6.00	7.40	0.70
	L14-S3	2.97	86.22	6.64	0.42	6.22	2.94	0.70
	L33-S1	5.59	84.05	3.42	0.34	3.08	6.16	0.70

**Table 4: Results of physico-mechanical tests for durability of dimension stone**

Rock Type	Bulk Density, D (Kg/m <sup>3</sup> ), ASTM C 97		Absorption by Weight Abs. ( %), ASTM C 97		Compressive Strength, Cu (MPa), ASTM C170		Abrasion by weight Abr. ASTM C 241	
	Required Value	Value Obtained	Required Value	Value Obtained	Required Value	Value Obtained	Required Value	Value Obtained
Coarse Granite	2560 min.	2620–2800	0.4 max	0.49–0.50	131 min.	87–134	10.3 min	17–41
Aplitic granite	2560 min.	2670	0.4 max	0.60	131 min.	119–230	10.3 min	31-56
Bhimsen Marble	2595 min. (I) 2800 min. (II) 2690 min. (III) 2305 min. (IV (I	2710	0.7 max	0.16-0.30	52 min.	116–229	10 min	32
Bhainse. Marble	Calcite, II Dolomite III Serpentine IV Travertine)							
Quartzite	2560 min.	2710	1 max	0.28	137.9 min.	135-225	8 min	71
Amphibolite	2560 min	3050-3100	1 max	< 0.11	137.9 min.	195-345	8 min	45-11

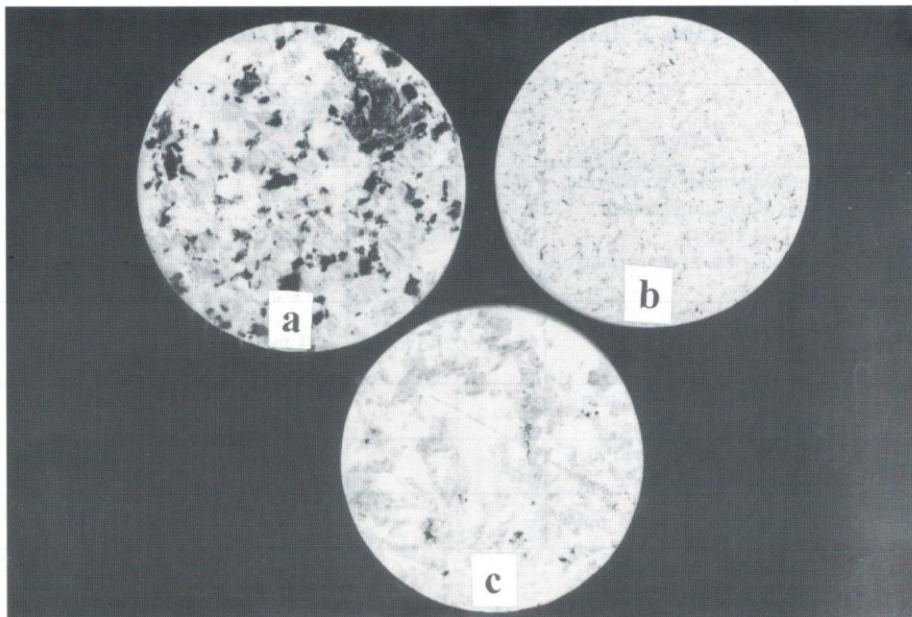


Fig. 3: Polished granite samples from Zone-1 (a) Coarse grained granite with biotite and tourmaline, (b) aplitic granite and (c) coarse grained granite with little biotite

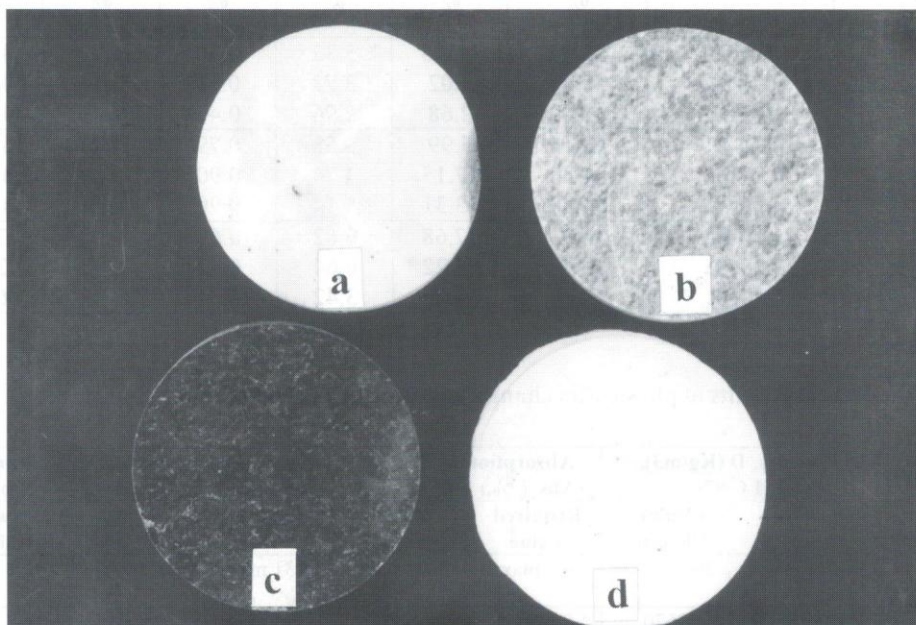


Fig. 4: Polished samples of (a) Bhainsedobhan Marble (b) Bhimsen Marble (c) Amphibolite and (d) Dunga Quartzite

Slightly weathered to fresh Palung Granite satisfies all the requirements specified by ASTM standards for durability of dimension stone. Coarse grained as well fine textured granite (aplite) has very attractive appearance after polishing and suitable for interior as well as exterior use. Out of the four zones delineated in Palung Granite, a huge mineable resource exists in Zone-1 and Zone-2. There are several small mineable deposits in Zone-3. The granite of Zone-4 is either far from the existing road network or highly weathered.

Light coloured Bhainsedobhan Marble, and bluish gray Bhimsen Marble have very attractive appearance on polishing and suitable for interior use. Both of them excellently met all the specifications required by ASTM standards for dimension stone. Though the Bhainsedobhan marbles in the area had already licensed to Hetauda Cement Industry, there are still some deposits that may be used for polished stone. The resources occurring at northern slopes from Bhainse to Okhardanda could be separated into several



small mineable deposits. Similarly, the deposits lying west of Kitini Khola also may be economically feasible and is in need of detailed study. Bhimsen Marble aside Poladanki Khola near Ikchun village possess a considerable deposit which could be easily mined. Bhimsen marble occurring at Chilaune, Nibuwater and Paribas villages are also appeared to be economic deposit however, further investigation is required.

Similarly, both milky white Dunga Quartzite and green amphibolite also excellently satisfy all the requirements specified by ASTM standards. The milky white polished surfaces of this quartzite are very attractive in appearance, luster and colorfast. As they will not be deteriorated by acid rain, both of them are marvelous for exterior as well as interior use. A huge deposit of Dunga Quartzite occurs nearly 1.5 km down stream of Taubas. Several deposits of quartzite exist at south of Nayagau, Kitinigau and north of Kisedi Khola. However, no huge deposits of amphibolite are noticed in the area. The available deposits need to be investigated in detail.

Hetauda Lime Industry is producing polished as well as unpolished slabs from boulders of Rapti River. The slabs are mostly of granite, marbles, quartzite and amphibolite. It is a great contribution of the private entrepreneur to the mining industry and shall be highly appreciated.

The results presented here are based only on preliminary investigations and laboratory results of only few selected samples, therefore further investigation of the area should be carried out for detailed evaluations.

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