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A Study of Petro chemistry and Geology of Granites of Jalore, Rajasthan

Dr. Anil Kumar Yadav
Associate Professor
Geology Govt. Dungar Collage, Bikaner Rajasthan

ABSTRACT: *A significant dimensional and ornamental stone is granite. Granite is the most sought-after stone to be utilized as a building as well as decorative stone since it is more resistant to wear and strain as well as weathering. Large granite reserves of numerous types are abundant in Rajasthan, and they are dispersed throughout the state's 23 districts. The state's top commercial granite producers are the Jalore and Barmer areas. These districts' granites are Neoproterozoic in age. The granites in the region exhibit a vast range of color, texture, and composition. Potash feldspar (orthoclase or microcline), quartz, and plagioclase are the primary minerals found in the granites of the region. Hornblende, reibeckite, biotite, aegirine, muscovite, apatite, zircon, and opaques are examples of accessory minerals. Chlorite and sericite are considered secondary minerals. Granites of both the subsolvus and hypersolvus categories are present, according to the mineralogy of the local granites. But most granites are subsolvus, or two feldspar granites.*
Keywords: *Granites, Commercial producer, subsolvus, Feldspar etc.*

I. INTRODUCTION

A significant dimensional and ornamental stone is granite. According to technical definitions, granite is a granulose rock with a light color that is primarily made up of quartz and potash felspars, with tiny amounts of plagioclase and mafic minerals like biotite, hornblende, pyroxene, iron oxides, etc. However, in commercial terminology, the term "granite" has evolved to refer to all crystalline rocks with attractive colors, durability to withstand quarrying, cutting, and polishing procedures, and widespread aesthetic application. Granite is the most sought-after stone to be utilized as a building as well as decorative stone since it is more resistant to wear and strain as well as weathering.

The American Society for Testing and Materials describes commercial granite as "a visibly granular, igneous rock generally ranging in color from pink to light or dark grey, and consisting primarily of quartz and feldspars, accompanied by one or more dark minerals." Any igneous rock that is closely related to granite, such as granodiorite, porphyry, gabbro, and dolerite, as well as metamorphic rocks like gneiss, are referred to as "granite," according to Walle and Heldal. According to the Granite Conservation and Development Rules, 1999, "Granite mean dolerites, granite gneiss, migmatites, gabbros, anorthosite, rhyolites, syenites, charnockites and any other igneous and metamorphic rock types which are (i) Amenable to be recovered as dimensional stone, (ii) Capable of taking polish, and (iii) Commercially exploitable".

II. MATERIAL AND METHODS

Geological Setup of Granite Deposits :

Large granite reserves of numerous types are abundant in Rajasthan, and they are dispersed throughout the state's 23 districts. Granite has been found in more than 200 locations so far. The districts of Jalore, Barmer, Pali, Sirohi, Barmer, Ajmer, Jaisalmer, Jhunjhunu, and Jodhpur are home to the majority of significant production hubs. Numerous scattered granitic emplacements from the Archean to the Neo-Proterozoic ages were found in Rajasthan. But the majority of granites used for commercial purposes date from the Meso through Neoproterozoic. The state's granites have a variety of mineralogy, pertochemistry, and emplacement history. The state's granites can be broadly categorized into five categories:

First, Archean Granites

Granites from the Paleoproterozoic Era

Meso-Proterozoic Granites

4. Delhi Granites

5. Granites that are Neo-Proterozoic

Neo-proterozoic granites are thought to be the source of the commercial granites found in Jalore and Barmer regions. The Malani Igneous Province is thought to include these granites. The Malani Igneous Province contains 15 granitic plutons. Malani Igneous Province granites can be broadly divided into three types:

Siwana Granites (Barmer District) and Jalore Granites (Jalore District)

• Malani Granites (in the district of Barmer)
According to some researchers, the Malani Igneous Province's magmatic genealogy is as follows:
SupergroupMarwar
------Unconformity----------
Dykes in Phase III (Acid to Basic Dykes)
Plutons and Ring Dykes from Phase II (Jalore, Siwana, and Other Granites)
Volcanic Phase I: Rhyolites, Dacites, Basalts, etc.
-------Unconformity----------
Supergroup from Delhi, Basement Rocks
The Jalore granites span a surface area of 17,000 square kilometers and consist of seven plutons. Salawas is home to the smallest pluton, whereas Jalore is home to the largest. Around Jalore city, Jalore granite hill ranges can be seen. On top of this granite stands the Jalore Fort. Bishangarh in the north and Kankhi in the northwest are reached by the granite outcrops. The granites may be observed as far south as Bhinmal. There are a few locations where there is an intrusive touch with rhyolites. The Siwana granites span a region of around 2000 square kilometers and consist of six plutons. The four primary Siwana granite localities are Siwana, Jasai, Mungeria, and Baisala. The granites of Siwana form an irregular, elliptical-ring-shaped structure. The granite is found in the other three locations as curvilinear intrusions on either side of volcanics. In the Barmer district, small, dispersed bosses of Malani granite can be found near Balera, Lunu, and Suwala.

Mineral Composition:

Potash feldspar (orthoclase or microcline), quartz, and plagioclase are the main minerals found in the granites of the region. Hornblende, reibeckite, biotite, aegirine, muscovite, apatite, zircon, and opaques are examples of accessory minerals. Chlorite and sericite are considered secondary minerals. The predominant mineral phase in the majority of the granites in the region is potash feldspar. The size and kind of potash feldspar present in the local granites varies; for example, some granites include microcline, while others contain orthoclase (Photograph 12). However, the majority of granites exhibit frequent perthic intergrowth. The perthite makes it easy to see the albite'sexsolution lamellae. According to Photograph 13, the perthites are lamellar, string-like, and braided. In these grains, alteration at grain borders occurs often. The grains displayed varying degrees of sericitization (Photograph 14).
Quartz:
The size of quartz grains varies, but they are always anhedral with a serrated border. Quartz is undisturbed, and in a few examples, strained quartz grains can also be visible.
Plagioclase: In several granite samples, tabular laths of plagioclase grains can also be seen. The albite twinning in these grains is clearly visible. Compared to potash feldspar, they have undergone less modification. Zoned plagioclase are also seen in some locations (Photograph 15).
Amphiboles:
These granites frequently contain the amphiboles reibeckite and hornblende. Both minerals have varied sizes and are subhedral. They exhibit pleochroism and two separate sets of cleavages. These minerals frequently undergo alteration (Photograph 16).
Biotite: These minerals are found as ancillary minerals and exhibit well-defined pleochroism. Apatite and zircon inclusions can be seen in biotite laths (Photograph 17).
Other minerals: Muscovite, apatite, zircon, aegirine, and iron oxides are accessory minerals found in a few granites (Photograph 18).

Grouping of Granites in the Study Area:

It is suggested to categorize granitic rocks according on the type of feldspar present. Subsolvus and hypersolvus are the two main divisions of the categorization (Tuttle and Brown, 1958). In contrast to subsolvus granites, which contain two different varieties of feldspar, hypersolvus granites only contain a single feldspar as a result of crystallization under very low water pressures. In hypersolvus granite, the feldspar is characterized by the presence of exsolution textures. This is due to the fact that the original crystal of the high temperature feldspar was fragmented into K-rich and Na-Ca-rich portions during the cooling phase. The high temperature feldspar was ternary, meaning it included equivalent amounts of the Ca, Na, and K components. Perthitic describes the resulting texture. High water pressures during crystallization lead to the production of two different types of feldspar in subsolvus or two feldspar granites. Plagioclase is present in the subsolvus rocks as discrete grains, whereas all soda feldspar is or was in solid solution in the potash feldspar in the hypersolvus rocks.
Granites of both the subsolvus and hypersolvus categories are present, according to the mineralogy of the local granites. But most granites are subsolvus, or two feldspar granites. The classification of granites according to feldspar is shown in Table 1.

Table 1: Categorization of the granites of the study area on the basis of feldspar

Hypersolvus Granites	Subsolvus Granites
JB-3 Rakhi Green, JB-4 Mokalsar Green, JB-7 Green Granite, JB-8 Golden Pearl, JB-13 Desert Green, JB-18 Merry Gold, JB-20 Mountain Green, JB- 28 Imperial Pink.	JB-2 Bala Flower, JB-5 Rosy Pink, (Medium), JB-6 Rosy Pink (Coarse), JB-9 Copper Silk, JB-10 Z. Brown, JB-11 S.R. Red, JB-12 Classic White, JB-14 Black Granite, JB-15 Chima Pink, JB – 16 Jeeraval White, JB-17 Royal Touch, JB-19 Sunrise Yellow, JB-21 Rosy pink (Dark), JB-22 Baltic Blue, JB-23 P.white, JB-24 Urban Classic, JB-25 Bala Flower, JB-26 Bala Flower, JB-27 Kharda Red

Modal Analysis and Classification

The actual mineral composition of a rock is identified through modal analysis and is expressed as a volume percentage. The modal composition was recommended for igneous rock nomenclature and classification by the International Union of Geological Sciences (IUGS) Sub-commission on the Systematics of Igneous Rocks. Based on the actual ratio of the different minerals that make up a plutonic rock, which is known as the mode, a plutonic rock can be classed mineralogically. The relative abundance of three minerals, namely quartz, alkali feldspars, and plagioclase, must be determined for the granitic rocks in order to conduct a modal analysis. On a ternary diagram, a modal classification is based on arbitrary class borders.

To distinguish and categorize the different forms of granite based on their mineralogy, the present study determined the mineral composition and their relative proportions in the various types of granitic rock exposed in the area. The modal analysis of 27 commercial granites from the research area is provided in Table 2. For classification and naming in accordance with the IUGS classification, Table 3 shows the modal percentages of quartz (Q), alkali feldspar (A), and plagioclase feldspar (P) of these granite samples.

According to Table 2, alkali feldspar predominates in the majority of the local granitic rocks, with the exception of Black granite and Platinum White granite. Alkali feldspar can range in concentration from 6.3% to 73.64%. Another prominent mineral found in these rocks, with a percentage ranging from 17.43% to 38.03%, is quartz. The bulk of granites also include pyroclase, however the concentration varies greatly. Plagioclase concentrations in granite vary from 1.4% to 43.12%, with very few granites being completely free of the mineral. Mica and amphiboles are always found in trace amounts in these granites.

The modal percentage of quartz (Q), alkali feldspar (A), and plagioclase (P) in these granites was used and recalculated to 100% for the petrological classification and nomenclature according to the IUGS classification scheme. According to the QAP diagram (Figure 1) based on IUGS categorization, none of the commercial granites in the region are considered to be typical granites. 27 granites are present, of which 12 are"Alkali - Feldspar Granites," 11 are "Syeno - Granites," 2 are "Monzo Granite," and one each is "Alkali - Feldspar Quartz Syenite" and "Granodiorite." Table 4 provides the classification and nomenclature of the commercial granites in the region.

Table 2 : Modal analysis of commercial granites of Jalore and Barmer districts

Sample No	commercial Name	K-F%	Q %	Plag %	Amp%	Pyr%	Mica%	Other%
JB-2	Bala Flower	31.43	62.35	3.25	1.25	0	1.32	0.4
JB-3	Rakhi Green	18.94	73.64	0	6.8	0	0.6	0.1
JB-4	Mokalsar Green	17.43	73.01	0	8.36	0	0	1.2
JB-5	Rosy Pink (Fine)	28.4	64.22	4.23	1.6	0	1.2	0.35
JB-6	Rosy Pink (Coarse)	26.2	62.0	8.7	1.2	0	1.7	0.2
JB-7	Green Granite	23.5	62.9	0	4.2	2.4	6.8	0.2
JB-8	Golden Pearl	21.2	71.5	0	4.9	0	0	0
JB-9	Copper Silk	33.5	38.5	18.9	4.3	0	3.5	1.3

JB-10	Z.Brown	22.5	64.7	1.4	4.2	3.2	2.8	1.2
JB-11	S.R. Red	24.4	66.8	4.7	2.3	0	1.8	0
JB-12	Classic White	20.5	53.97	18.9	1.23	0	5.1	0.3
JB-13	Desert Green	21.23	66.82	0	10.4	0	1.34	0.21
JB-14	Black granite	19.28	6.3	43.12	15.8	0	12.9	2.6
JB-15	Chima Pink	24.26	38.5	24.27	7.97	0	4.25	0.75
JB-16	Jeeraval White	25.4	48.35	18.3	2.5	0	4.8	0.65
JB-17	Royal Touch	29.7	56.88	4.7	3.8	0	4.2	0.72
JB-18	Merry Gold	32.36	59.39	0	4.9	0	2.6	0.75
JB-19	Sunrise Yellow	28.4	42.05	18.9	4,3	0	5.7	0.65
JB-20	Mountain Green	38.03	53.47	0	3.8	0	4.7	0
JB-21	Rosy Pink (Dark)	26.12	48.58	12.8	4.9	0	6.3	1.3
JB-22	Baltic Blue	29.31	45.05	6.12	3.1	0	16.1	0.32
JB-23	Platinum White	35.08	30.5	19.01	2.5	0	11.5	1.4
JB-24	Urban Classic	34.15	42.71	17.11	0	0	6.03	0
JB-25	Bala Flower	28.05	54.37	7.15	3.1	0	5.3	2.03
JB-26	Bala Flower	31.1	51.1	6.5	4.2	0	5.6	1.5
JB-27	Kharda Red	34.05	40	17.15	3.5	0	4.1	1.2
JB-28	Imperial Pink	31.38	58.21	0	4.85	0	4.35	1.10

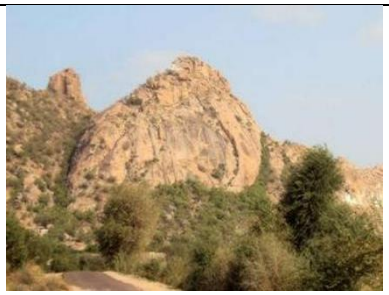
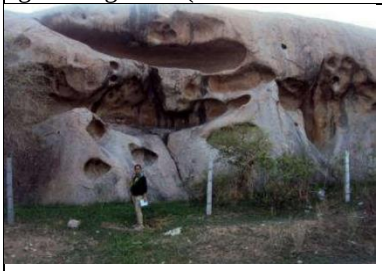
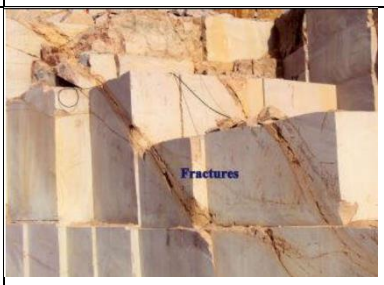
K-F = Potash Feldspar, Q = Quartz, Plag = Plagioclase, Amp = Amphiboles, Pyr = Pyroxene

Table 3 : Modal percentage of commercial granites

Sample No	Commercial name	Q%	A%	P%
JB-2	Bala Flower	32.39	64.25	3.34
JB-3	Rakhi Green	20.45	79.54	0
JB-4	**M**okalsar Green	19.27	80.72	0
JB-5	Rosy Pink (Fine)	29.32	66.3	4.36
JB-6	Rosy Pink (Coarse)	27.03	63.98	8.97
JB-7	Green Granite	27.1	72.8	0
JB-8	Golden Pear	22.86	77.13	0
JB-9	Copper Silk	36.85	42.35	20.79
JB-10	Z. Brown	25.39	73.02	1.58
JB-11	S.R. Red	25.44	69.65	4.9
JB-12	Classic White	21.95	57.8	20.24
JB-13	Desert Green	24.11	75.88	0
JB-14	Black granite	28.06	9.17	62.76
JB-15	Chima Pink	27.87	44.23	27.88
JB-16	Jeeraval white	27.59	52.52	19.88
JB-17	Royal Touch	32.53	62.31	5.14
JB-18	Merry Gold	35.26	64.73	0
JB-19	Sunrise Yellow	31.78	47.06	21.15
JB-20	Mountain Green	41.56	58.43	0
JB-21	Rosy Pink (Dark)	29.85	55.52	14.62
JB-22	Baltic Blue	36.41	55.97	7.6
JB-23	P. White	41.48	36.06	22.47
JB-24	Urban Classic	36.34	45.46	18.2
JB-25	Bala Flower	31.31	60.7	7.98
JB-26	Bala Flower	35.06	57.6	7.3
JB-27	Kharda Red	37.33	43.85	18.8
JB-28	Imperial Pink	35.02	64.97	0

Q = Quartz, A = Alkali feldspar, P = Plagioclase

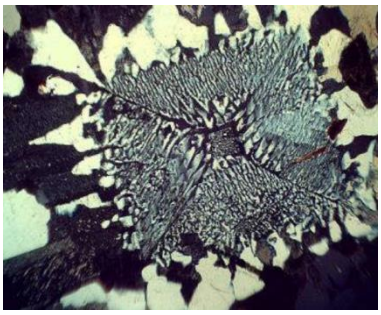
Table 4: Classification and nomenclature of the commercial granites of the study area

Nomenclature and Classification based on IUGC – QAP	**Commercial Granite of the Class**
Alkali – Feldspar Granite	Bala Flower (JB-2), Rakhi Green (JB-3), Rosy Pink Fine (JB-5), Green Granite (JB-7), Golden Pearl (JB-8), Z. Brown (JB-10), S.R. Red (JB11), Desert Green (JB-13), Royal Touch (JB-17), Merry Gold (JB-18), Mountain Green (JB-20), Imperial Pink (JB-28)
Syeno– Granite	Rosy Pink Coarse (JB-6), Copper Silk (JB-9), Classic White (JB-12), Jeeraval White (JB-16, Sunrise Yellow (JB-19), Rosy Pink Dark (JB-21), Baltic Blue (JB-22), Bala Flower (Jb-25), Bala Flower (JB-26), Kharda Red (JB-27)
Monzo – Granite	Chima Pink (JB-15), P. White (JB-23)
Alkali – Feldspar – Quartz Syenite	Mokalsar Green (JB-4)
Granodiorite	Black Granite (JB-14)
 Photograph 1: Granite exposure in Jalore area	 Photograph 2: Vertical basaltic dyke within the granitic rocks at Village Dhawla, Jaolre
 Photograph 3: Gradational contact between fine and medium grained granite (Fine at Left and Medium at Right)	 Photograph 4: Contact between Desert Green and Golden Pearl granite, Devda village, Jalore
 Photograph 5: Weathering in granites (Tuffoni caves)	 Photograph 6: Large scale fractures in the granites causing difficulty in block formation

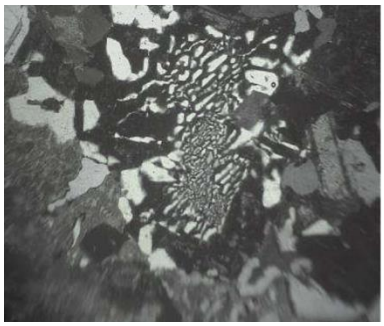
Photograph 7: Showing the Fine grained,equigranular variety of granite (Sample JB-5).

Photograph 8: Showing the Coarse grained,equigranular variety of granite (Sample JB6).

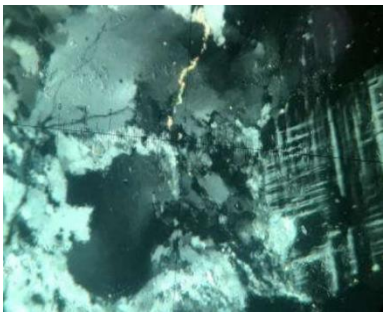
Photograph 9: Showing the inequigranular texture with Rapakivi structure (Sample JB9).



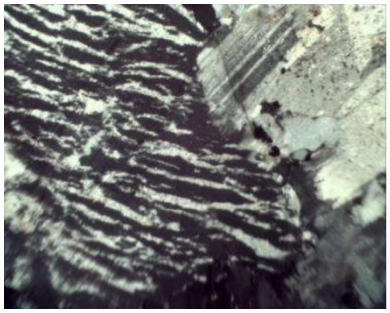
Photograph 10 : Myrmekitic structure showing intergrowth of quartz and plagioclase (Sample JB-5)



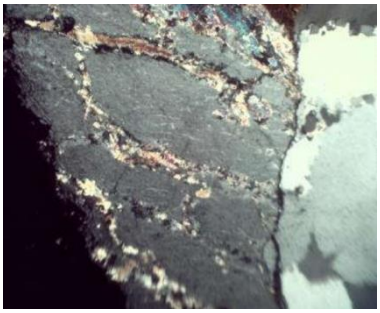
Photograph 11 : Graphic intergrowth showing intergrowth of potash feldspar and quartz (Sample JB-2).



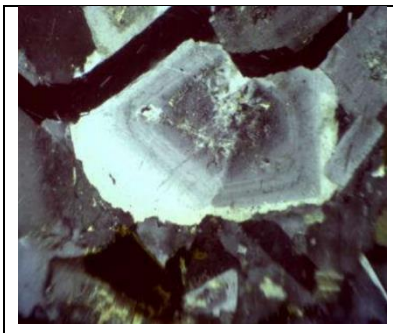
Photograph 12 : Granite with microcline and anhedral quartz (Sample JB-24).



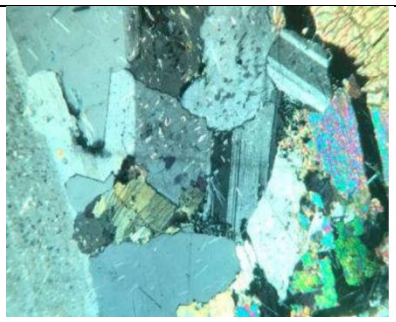
Photograph 13: Orthoclase-perthite with exsolution lamellae of albite (Sample JB-27).



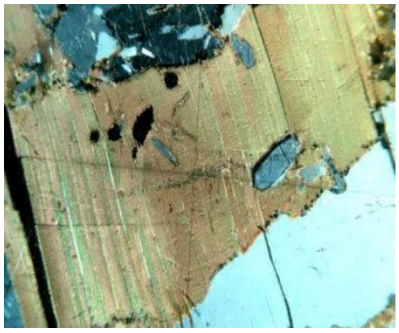
Photograph 14: Showing the alteration to sericite in potash feldspar (Sample JB-22)



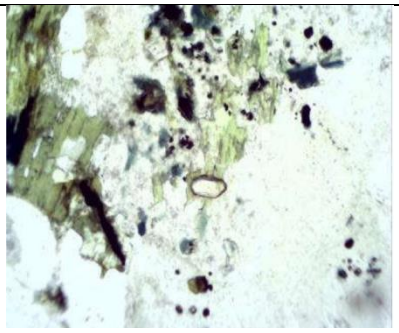
Photograph 15: Zoned plagioclase in granite (Sample JB-16).



Photograph 16 : Showing subhedral grains of altered perthite, plagioclase and reibeckite (Sample JB-15)



Photograph 17 : Inclusion of apatite and quartz within the biotite grain (Sample JB-14)



Photograph 18 : Inclusion of zircon grain within the hornblende grain (Sample JB-21).

III. DISCUSSIONAND CONCLUSIONS

Inordertobetterunderstandthenatureofgraniteemplacement,thefieldrelationshipsbetweenvariousgraniticrocksandwithotherigneousrocks,texturalandstructuralvariations,andthecollectionofrepresentativesamplesforpetrologicalstudies,extensivefieldvisitsweremadetovariousplutonsandminesintheJaloreandBarmerdistrictsduringthecourseofthecurrentstudy.Regardingthegeology,natureandfieldrelationships,texturalandstructuralcharacteristicsofgraniticrocksintheresearchregion,thefollowingobservationsweremade:

- Thebasementrocksaregenerallynotexposedinthearea,butmanyplacesthereisasharpcontactwithMalanirhyolites,indicatingthatmostofthegraniticrocksareemplacedduringpost-Malaniphase.
- Thegraniticrocksintheareaareoccurringasisolatedplutonsofvariableinshapeandsize,i.e.,informofstocksandboss(Photograph1).
- ThegraniticrocksintheJaloreareafrequentlyshowintrusionsofbasalticdykesthathavecoolingeffectsupto5metersoneitherside(Photograph2).
- Thegranitesintheareaexhibitawiderangeofcolorandtexture.Eachplutonoftenhasauniquetypeofcolorandtexture.Grayishwhite,lightpink,darkpink,reddishbrown,lightyellow,yellowishbrown,lightgreen,green,grayishgreen,andotherhuesareamongthecolorsofgranite.Similartothegrainsize,thetexturerangesfrombeingevenlydistributedtobeingunevenlydistributed.Gradationalcontactbetweengraniteswithfine,medium,andcoarsegrainscanalsobedetectedinsomelocations(Photograph3).
- Gradationalcontactbetweenbrightanddarkcolorsinsidegranitesisacharacteristicthatisfrequentlyseeninnature,muchliketexture.Thereisonlyonelocation,DevdainJalore,wheretheyellowish(GoldenPearl)andlightgreen(DesertGreen)varietiescomeintosharptouch(Photograph4).
- Inthegranites,rhyoliticandmaficxenolithshavebeenfoundinnumerouslocations.
- Thelocalgraniteexhibitsavarietyofweatheringphenomena,includingexfoliation,spheroidalweathering,pan-holeweathering,tuffoni,etc.(Photograph5).
- Jointingisacommonstructuralelementpresentinthegranites,andtherearenoobvioussignsofdeformationinthelocalgraniticrocks.Therehavebeenreportsofvertical,horizontal,andinclinedjointingintwotothreesets.
- Atsomelocations,thegraniticrocksarefractured,loweringtheircommercialworth(Photograph6).•Thejointingintheserocksisparticularlyessentialinthecreationofblocksforcommercialusage.

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