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ENVIRONMENTALLY SAFE RAW MATERIALS FOR BLASTING APPLICATIONS: THE GARNETITES OF KIMMERIA (XANTHI) AND SERIFOS ISLAND

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ΠΕΡΙΛΗΨΗ

Δείγματα γρανατιτών απο τα ασβεστούχα skarns των Κιμμερίων Ξάνθης και της Σερίφου υπέστησαν επεξεργασία ώστε να παραχθούν δύο κοκκομετρικά κλάσματα (+0.3 έως -2.38mm και -0.3mm) για δοκιμές καταλληλότητας για εφαρμογή σε αμμοβολές. Το αδρόκοκκο κλάσμα αποδείχθη καταλληλότερο για καθαρισμό μεταλλικών επιφανειών καλυμμένων με παχύ στρώμα σκουριάς. Οι δοκιμές έδειξαν ότι ο γρανάτης των περιοχών αυτών είναι αποτελεσματικότερος από τη χαλαζιακή άμμο και τη μεταλλουργική σκουριά που χρησιμοποιείται σήμερα. Το ποσό της σκόνης που εκπέμπεται κατά τη διαδικασία της αμμοβολής είναι σημαντικά μικρότερο και η διάρκεια καθαρισμού μιάς επιφάνειας είναι επίσης μικρότερη σε σχέση με τη χαλαζιακή άμμο και τη σκουριά. Επιπλέον απαιτούνται συγκριτικά μικρότερες ποσότητες υλικού και εμφανίζεται ικανοποιητική ανακυκλωσιμότητα.

ABSTRACT

World demand for industrial garnet increased last years. Garnet has become a replacement of silica sand and slags in sandblasting operations. Garnet testwork samples of this study originated from calcitic skarns in two contact metamorphic aureoles of young granodiorites from Northern Greece (Kimmeria, Xanthi) and Cyclades (Serifos island). Samples were crushed and screened so that two screen fractions were produced: -2.38mm to +0.3mm and -0.3mm. Pressure sandblasting evaluation was conducted on several samples. Best results for blast cleaning of heavily corroded metallic surfaces were obtained on the coarse fraction of all samples. Garnet sandblasting provided a super clean surface for protective coating and preparing surfaces for painting.

KEY WORDS: andradite, garnet, pressure blasting, abbrasives, skarn, Kimmeria, Serifos, Greece.

1. INTRODUCTION

In the last years the world market shows strong interest for environmentally safe abrasive materials. The silica ban in England and restrictions by several countries in the use of silica sands and also slags containing leachable toxic metals, resulted in expansion of demand for environmentally safe resources. Given that silica sand is used in the largest volumes for abrasive cleaning, even a small reduction in its use opens uplarge volume markets for other natural or synthetic abrasives (KENDALL, 1997). Although natural abrasives have had market share taken away by synthetic materials produced in vast quantities, world demand for garnet, olivine and staurolite increases. Following the introduction of environmental laws, these minerals are finding increased favour, relating to free silica. They are relatively low cost, silica free materials, which protect workers from silicosis desease. Garnet, because of suitable physical and chemical properties, is very efficient when applied to air blasting, polishing and water filtration. The

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largest market of garnet is sand blasting in shipyards, oil rigs, pipes, and various plant equipmnets, whereas slags, olivine, staurolite and fused alumina are its main competitors.

A significant number of garnet deposits – which are found out of the borders of a few producing countries – are now under evaluation worldwide. Research projects to test the suitability of garnets from Greek garnetiferous rocks for industrial applications were not set previously. Because world demand for garnet is forecast to double over the next decade, a preliminary research project for several occurrences in Greece was considered necessary, in order to test the suitability of the material in sandblasting applications. Occurrences of garnetites from two contact metamorphic aureoles attracted our interest first, because they are almost monomineralic and processing techniques were not necessary to be applied to remove associated minerals for the production of high purity concentrates.

This paper aims to present the results of the preliminary research on evaluation of garnetites of Kimmeria and Serifos for sandblasting applications.

2. GARNET PRODUCTION – DEMAND

Garnet world market depends on the production of a few countries. U.S.A. was the largest garnet producer and exporter until the early 90's, with over 45% of world production as shown in Table 1, now becoming a net importer. However in 1995 Australia and India reached productions of 70,000 tn and 60,000 tn respectively. In the last six years world garnet consumption has been increasing at about 20-25% per annum. This increase resulted in expansion of world production (about 500% in the time period between 1984 to 1996). The boom in demand for garnet is mainly due to the fact that garnet has become increasingly popular for the blast cleaning of metallic surfaces. Other sectors having contributed to the rise in demand are the water filtration and water jet cutting systems (DICKSON, 1982; KENDALL, 1997).

Table 1. World garnet production in 1991 (HARBEN, 1992)

Garnet production (in tons) (USBM, 1991)		*Garnet exporting countries*	*Garnet importing countries*
U.S.A	65.000	Australia	France
Australia	25.000	USA	Germany
China	20.000	Sri Lanka	Korea
Ex.USSR	2.000	China	Netherlands
Norway	8.000		Taiwan
India	28.000		Great Britain
Turkey	700		USA
Sri Lanka	100		

From the data presented in Table 1 it is concluded that garnet is not produced in the European Union, whereas in Europe only Norway and Turkey are garnet producers. Thus Europe may be considered as a ready market. It is worth mentioning that the companies "McAlpine" and "Microfine" will probably develop deposits and a processing plan for production of garnet concentrates from schists in Scotland. A project for alluvial garnet is running in Liguria prefecture in Italy. Presently, the production of garnets is a top priority for several countries in Eastern Europe (e.g. Ukraine, Chech Republic), as it would replace more expensive products being used, as well as provide much needed currency from exports.

3. GEOLOGICAL SETTING OF GARNETITES

The garnetites of skarns from two contact metamorphic aureoles were selected from various garnetiferous rocks of metamorphic units in Greece. Due to the high modal proportion of garnet in the garnetites (roughly 95%) only a small scale processing of the material is needed for the production of a high purity concentrate. From all known contact metamorphic aureoles in Greece, those of Kimmeria (Xanthi) and Serifos island in Cyclades (Fig. 1) were chosen, because of their relatively big areal extent, the purity of the material and the large grain size of garnet crystals.

Research exploration projects carried out in Kimmeria (Xanthi) in late 70's, were focused in skarn - type wollastonite and W, Cu and Mo mineralization. The petrology and ore deposit geology of the contact metamorphic aureole was studied by AUGUSTITHIS (1971); AYME et al. (1976); LIATI (1986); SKARPELIS (1990) and SKARPELIS & LIATI (1991). Garnetite testwork samples originated from calcitic skarns close to the contact with the surrounding marbles. The garnetite reserves were estimated at

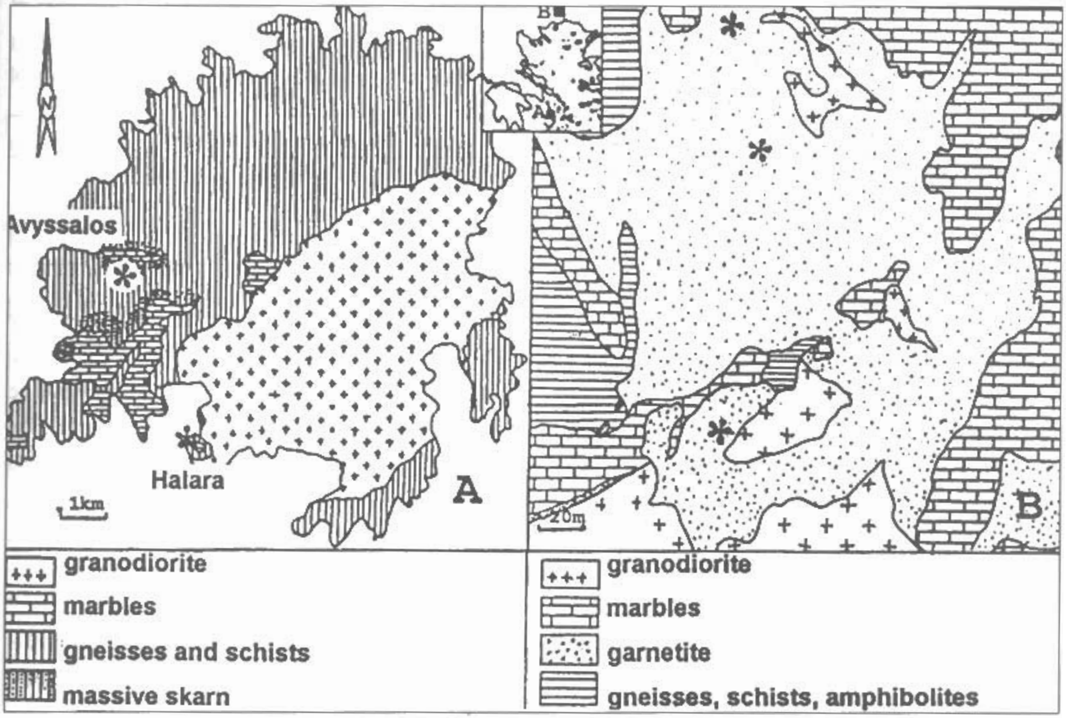

Fig. 1: Simplified geologic maps of Serifos island (A) and Kimmeria (B) from SALEMINK (1985) and LIATI (1986) respectively. Sample locations are indicated with asterisks.

3 Mt by AYME et al. (1976). The garnet of the skarn is pale brown to yellow-green in colour, very rich in andradite molecule, and associated with pyroxene, epidote, wollastonite and magnetite. It is commonly anisotropic with alternating isotropic and birefringent lamellae parallel to the (110) growth planes and usually shows sector twinning. Calcite and/or epidote occur as alteration minerals of garnet.

Garnetites of Serifos form large – often monomineralic – bodies within the calcitic skarns. In this case garnet is isotropic and rich in the andraditic molecule (Ad 100-90, Gr 0-10). Vein filling garnet, associated with magnetite and pyroxene in massive skarns, is rich in grossular (Ad 70-60, Gr 30-40) (VERGOUVEN, 1976; SALEMINK, 1985).

4. PROCESSING METHOD AND SANBLASTING TESTS

Several samples of garnet-rich material were collected, each weighting around 25 kgs. Location of samples is indicated in Fig. 1. Jaw crushers were used first for the production of relatively coarser fractions and roll crushers for the fine ones; thus production of extreme fines was minimized. Two screen fractions of angular grains were produced, taking in consideration the grain sizes required by industry: -2.38mm to +0.3mm and -0.3mm. The coarse fraction may be used for cleaning of heavily oxidised metallic surfaces, whereas the fine one for etching of glass and plastics. Each screen fraction was washed for dust removal and dried to 60°C prior to pressure sandblasting evaluation. Microscopy and X-ray diffraction was applied for identification of mineral impurities in the concentrates. The proportion of each fraction produced after processing of the samples is indicated in Table 2.

Pressure sandblasting evaluation was conducted on several samples. Heavily corroded metallic parts of old machines, left in the former electric power station of the Public Power Corporation (Moshato area, Piraeus), were sandblasted. We used the same blowers and we followed the same operation procedures as

Table 2. Average percentages (wt%) of screen fractions produced after processing of the samples

Sample locations	*fraction +0.3 to 2.38mm (wt%)*	*fraction -0.3mm (wt%)*	*dust*
Kimmeria (Xanthi)	86.5	13.0	0.5
Chalara (Serifos)	85.0	14.5	0.5
Avyssalos (Serifos)	84.0	12.4	3.6

for silica sand and slags. Evaluation of the results of sandblasting is empirical, because international or national standards for laboratory tests are not yet established. Information gathered from the Hellenic Organisation for Standardisation (ELOT) refers to preparation of a draft standard, which probably will be attached to ISO 11126. Thus evaluation is based on the experience of sandblasting operators. The important considerations in appraising abrasive value are: the cleaning rate, the amount of material consumed, the quantity of dust generated during sandblasting and the quality of polishing of the surface. The garnet from Kimmeria and Serifos has been proven against silica sand and ferronickel slag to give faster cleaning action. It produces a good finish on metals and provides a super clean surface for protective coating and preparing for painting. The dust generated during blasting operations was minimal. Good visibility enables the operator to see his work clearly. The results obtained on all the coarse garnet fractions used were similar. The efficiency of the Kimmeria and Serifos garnet is atributed mainly to the particle shape (Fig. 2), which is considered as a fundamental physical property in selecting an abrasive for sandblasting application. The blocky and nearly equidimensional grains are identified as strong-shaped and are less friable than flaky ones. Most probably this is due to the lamellar texture of the garnets, causing the crystal to break down into sharp irregular grains.

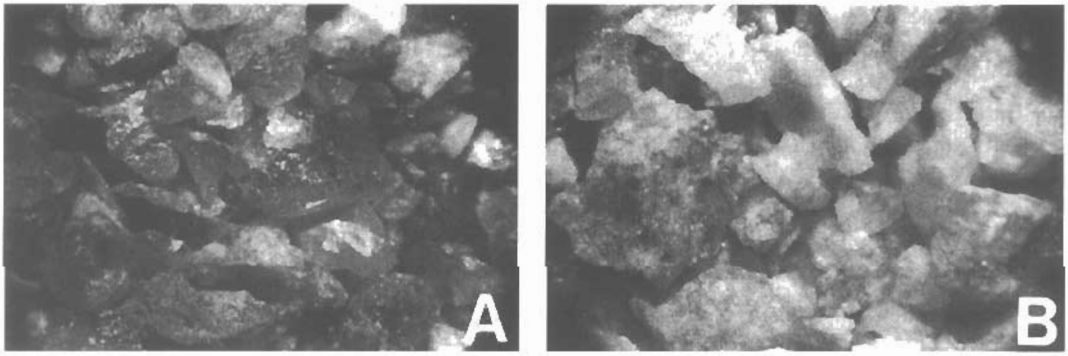

Fig. 2: Blocky particle shape of garnet fraction +0.3 to -2.38 from Serifos (A) and Kimmeria (B)

5. DISCUSSION

The prices of garnet concentrates are higher in comparison to the prices of other sandblasting materials, especially slags. For Idaho almandine (8-250 mesh) FOB prices (mine) in January 1998 ranged between US$ 180 and 240, whereas for andradite (12-80 mesh) between US$180 and 400 (Industrial Minerals, January 1998). The low cost of silica sand and slag results to - still - a wide use. Nevertheless, it is garnet which is showing the highest growth rates in the blasting market relative to competitive materials, because it offers some major advandages for blast cleaning:

a. Superior hardness (6.5-7.5 Mohs scale for andradite); only diamond and corundum among natural abrasives have higher hardness than garnet.

b. Garnet, from a health and worker safety standpoint, is one of the safest materials on the abrasive blasting market, being chemically inert; the concentrates usually are silica free and do not contain leachable heavy metals.

c. It is recyclable, because it has very low particle breakdown on impact, thereby minimizing dust generation and resulting in a longer life span.

d. Garnet grains are not bonded to the metallic surfaces upon impact.

The results of the testworks of Kimmeria and Serifos garnets are encouranging in follow-up research for industrial evaluation. Taking in consideration the fact that the use of garnet as a blasting medium is expected to expand considerably and that several tectonic units comprise garnetiferous rocks, it is concluded that exploration for economic garnet resources in Greece should be intensified.

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