Available online at www.pelagiaresearchlibrary.com

Pelagia Research Library

Advances in Applied Science Research, 2012, 3 (2):1880-1888

Pelagia Research Library

ISSN: 0976-8610
CODEN (USA): AASRFC

The behaviour of Feldspar Megacrysts in Granitic Pegmatite Veins (western Oban massif, Nigeria)

Oden, M.I.[1] and Igonor E.E.[2]

[1] Department of Geology, University of Calabar, Calabar, Nigeria
[2]Petra Prospectors Limited (Abuja, Nigeria)

ABSTRACT

Megacrysts of feldspar occur randomly and abundantly in pegmatite veins hosted by gneisses in the Oban massif (SE Nigeria). Earlier work has shown that these megacrysts are k-feldspars and magmatic products, formed at liquidus temperature in the presence of enough liquid that allowed the crystals to flow. Megacryst size, frequency and other physical characteristics were used to unravel their nucleation and crystal growth history. Analyses of over 400 megacrysts present in the pegmatite veins, showed that: (a) larger megacrysts occur closer to the middle of the veins, while smaller ones occur near the vein wall; (b) the smaller grains have larger angle difference between their long axes and the vein wall, while the longer grains have smaller angle difference; and (c) the wider veins contain larger-size but fewer grains, while the narrower veins contain smaller but more grains. It is deduced that the large-size megacrysts, which are also fewer in frequency, are most likely crystals that nucleated and started growing during a small degree of temperature change (during the cooling of the magma melt). Under favourable conditions they grew to large sizes, while the more abundant and smaller-sized megacrysts nucleated and grew during a greater degree of temperature change. Since under such conditions nucleation and growth rates are high, with the crystals competing for solute particles, more abundant but smaller sizes of megacrysts were formed.

Keywords: nucleation, crystal growth, supercooling, flowage, chaotic orientation,

---

INTRODUCTION

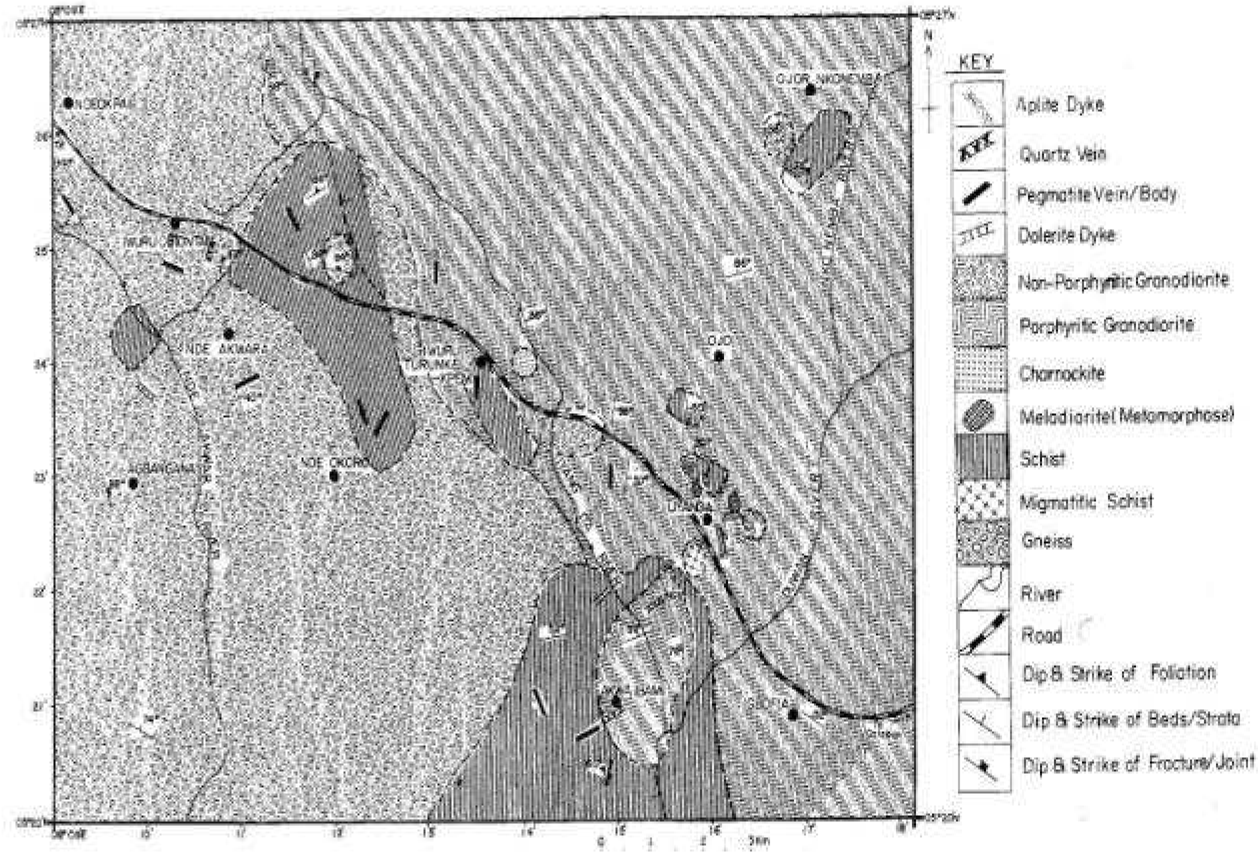
Feldspar megacrysts abound in the basement complex rocks of the Oban massif. They are either in the porphyritic granodiorite or present in the pegmatite veins, which occur ubiquitously in the area. A more detailed description of the pegmatite and host rock is provided by [1].

The study area is a part of the Precambrian mobile belt of Nigeria, in the western part of the Oban massif, SE Nigeria. This area is traversed by the coordinates 8^{o} 00' – 8^{o} 30'E and 5^{o} 00' – 5^{o} 30'N.

Information on the origin, source and formation history of megacrysts in the Oban massif is scarce. [2]suggested that Na^+ and K^+ enrichment was as a result of the rejuvenation of the basement rocks during the Pan-African Orogeny, which possibly triggered off K^+ and Na^+ metasomatism, that must have led to crystallization of k-feldspar megacrysts. [3] later estimated that it took long (about 108 Ma) for the host rocks to cool which indicates very slow cooling rate, which explains the abundance of k-feldspar megacrysts in granodiorite of the Oban massif.

MATERIALS AND METHODS

Over 400 megacrysts occurring in about 28 pegmatite veins hosted by gneissose rocks were studied. The data collected include grain length, width, and distance from the vein wall. Also the angles between the long axis of the crystals and the vein walls were measured. Evidences from physical observations like; shape and sizes of megacrysts, alignment of megacrysts in rocks, assembling pattern of megacrysts, and also petrographic studies, chemical and structural characteristics had earlier shown that these megacrysts are of magmatic origin (phenocrysts) and were formed at liquidus temperature in the presence of enough liquid to allow the crystals to flow. Assuming no dissolution took place, crystal size would be dependent on its time of nucleation and subsequent growth rate [4], which means that the frequency of crystal sizes provides a record of the nucleation and growth history of an igneous rock. This paper aims at unravelling the nucleation and crystal growth history of the megacrysts in pegmatite veins using their physical characteristics.



Geologic map of study area

Geologic setting

The Oban massif is an area that has been affected by major, tectonic, magmatic and metasomatic events which are common also in other crystalline basement areas of Nigeria [5], [6] [7], and [8]. Consequently, the Oban massif has been identified to be made up of three main lithologic units: (1) Migmatitic and sheared gneissic rocks, schists, phyllites, meta-conglomerates and quartzites, amphibolites and meladiorites, deformed pegmatites and aplites, and pyroxenite – which forms the basement rocks as in other Basement Complex areas of the country; (2) Older Granite intrusive series comprising meladiorites, granodiorites, adamellites to granitic rocks; pegmatites, aplite and quartz veins; (3) Unmetamorphosed dolerite to microdioritic intrusives.

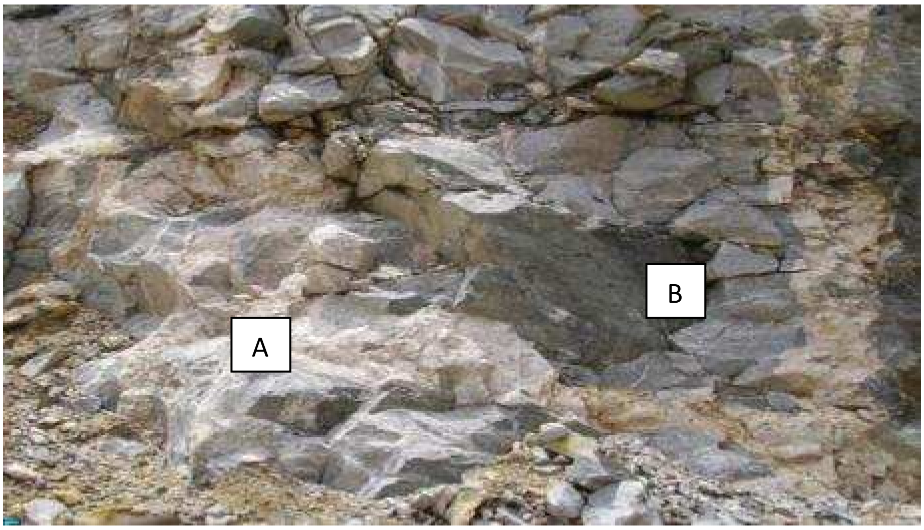


Fig. 1) Pegmatite veins with megacrysts running (A) concordantly and (B) discordantly to the general trend of the host rock. They have been exposed at a quarry pit by blasting.

Fig 2, Large pinkish megacrysts in the middle of a pegmatite vein (pen is 15cm).

Fig. 3. Randomly oriented megacrysts in pegmatite vein(pen is 15cm).

RESULTS

Description of pegmatite veins

The pegmatite veins are hosted by banded and granite gneisses. These veins run sometimes concordantly and at other times discordantly to the general trend of the foliation of host rock (fig. 1). They vary in length and width, they sometimes exceed 200 m in width; widths also vary from as small as 3cm to more than 50 cm. These undeformed pegmatite veins are generally barren of any rare metal in economic concentration, except for very few green tourmaline grains.

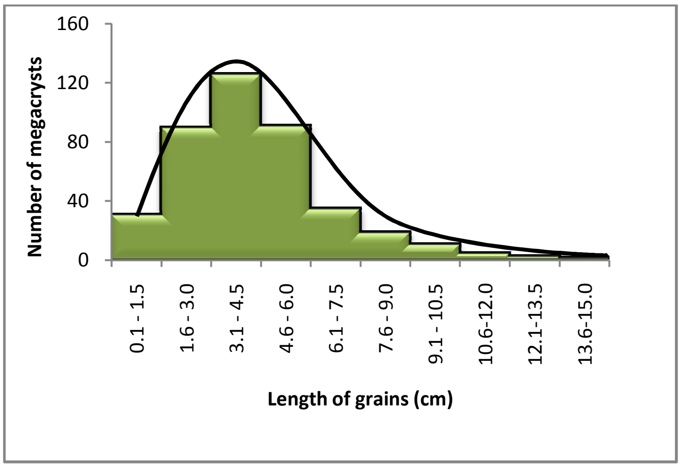


Fig. 4a: 3.1 – 4.5 (cm) is the highest frequency of grain lengths of the megacrysts; megacrysts frequency increases until megacrysts length reaches a maximum at 3.1-4.5 cm. After that megacrysts frequency decreases with increase in length

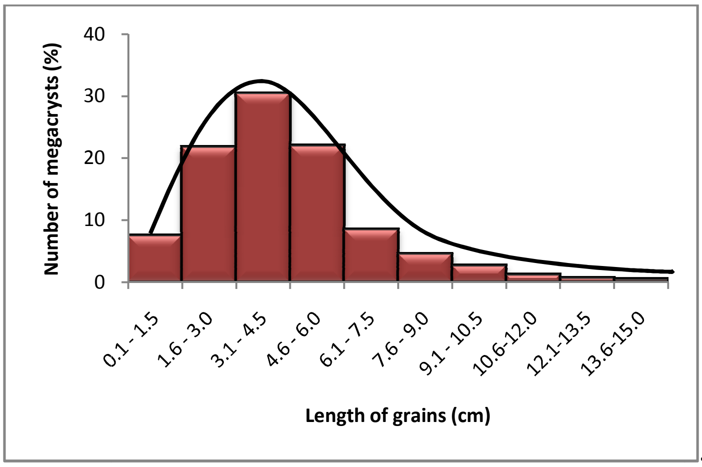


Fig. 4b: the megacrysts vary in frequency (%) with increase in grain length; megacrysts frequency increases until megacrysts length reaches a maximum at 3.1-4.5 cm. After that megacrysts frequency decreases with increase in length.

Description of megacrysts

The megacrysts present in the pegmatite veins are very conspicuous and abundant. They are best studied in quarries where blasting has helped expose them (Fig. 1). These megacrysts are pinkish – whitish in colour, with square or rectangular subhedral-euhedral shapes and sizes ranging from 0.6 cm x 0.4 cm to 14.5 cm x 1.4 cm (Fig. 2). They occur randomly, with no preferred orientation (Fig. 3). In thin sections these megacrysts show uniform distribution of crystals with simple twinning. Mineralogical and geochemical analyses have shown these megacrysts to be k-feldspar [1]. Megacrysts with lengths between 1.6 cm and 6.0 cm, account for more than 70 % of all gains studied, even though the highest occurring length size is between 3.1 cm and 4.5 cm (which is about 30 % of all grains) (Figs. 4a and 4b). The grain widths between 0.6 cm and 2.5 cm, account for more than 80 % of all grains, while the highest occurring width size is between 1.1 cm and 1.5 cm (Figs. 5a and 5b). The average length and width of the megacrysts in each vein increases as the pegmatite vein sizes increase (Figs. 6a and 6b; 7a and 7b). Similarly, the distances from the central line of megacrysts to the vein wall increase as the length of the megacrysts also increases (Fig. 8).

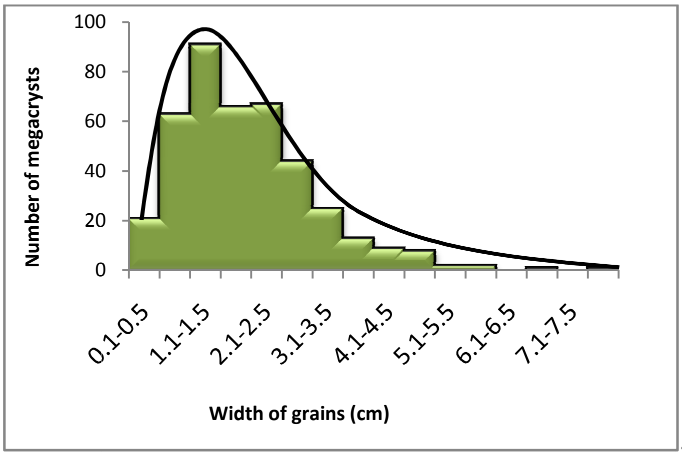


Fig. 5a:1.1 – 1.5 (cm) is the highest frequency of grain width of the megacrysts; megacrysts frequency increases until megacrysts width reaches a maximum at 1.1 - 1.5 cm. After that megacrysts frequency decreases with increase in width.

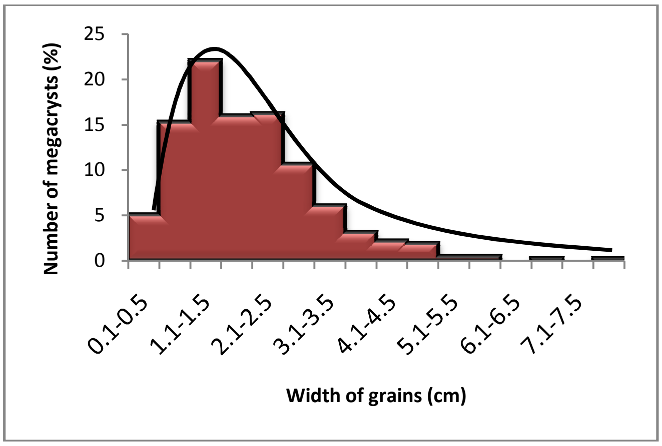


Fig. 5b: how the megacrysts vary in frequency (%) with increase in grain width; megacrysts frequency increases until megacrysts width reaches a maximum at 1.1 - 1.5 cm. After that megacrysts frequency decreases with increase in width.

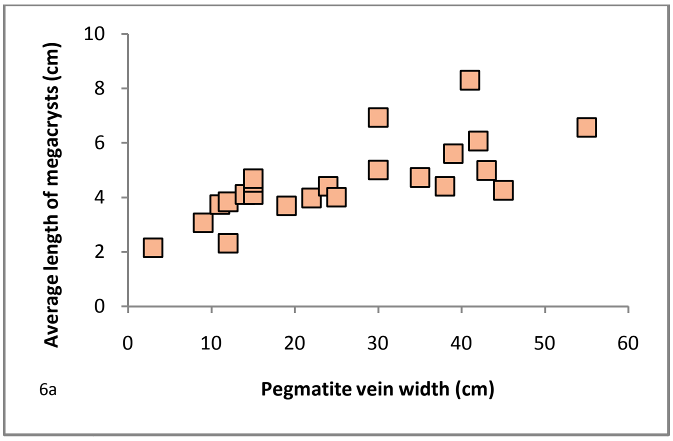


Fig. 6a the average length of the megacrysts in each vein increases as the pegmatite vein sizes increase

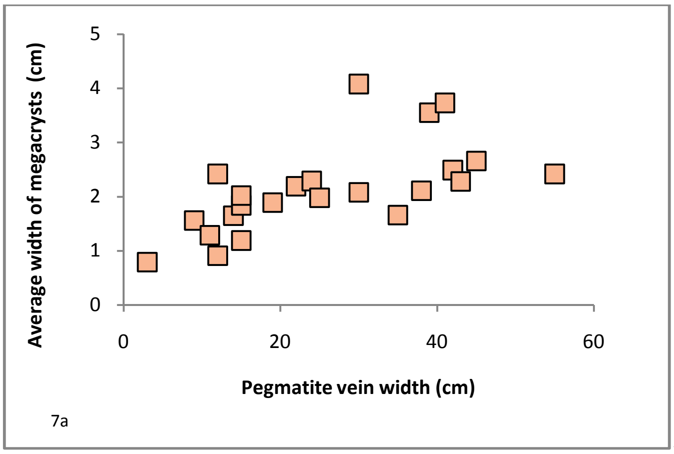


Fig. 7a Scatter plot of how the average width of the megacrysts in each vein increases as the pegmatite vein sizes increase

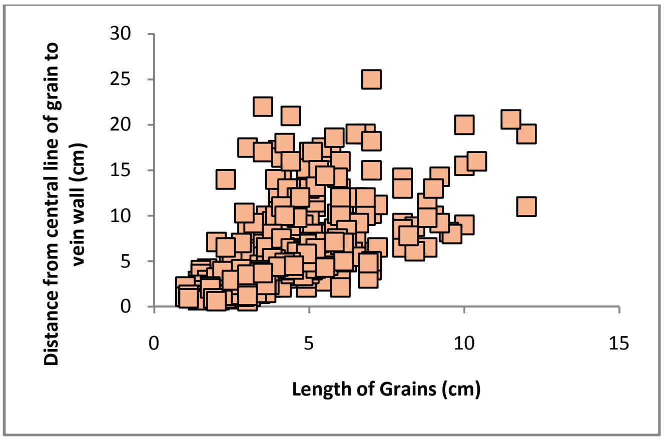


Fig. 8: Megacrysts length increases as the distance from vein wall increases so that the longer grains are found in the middle of the veins while the shorter ones are closer to the vein wall

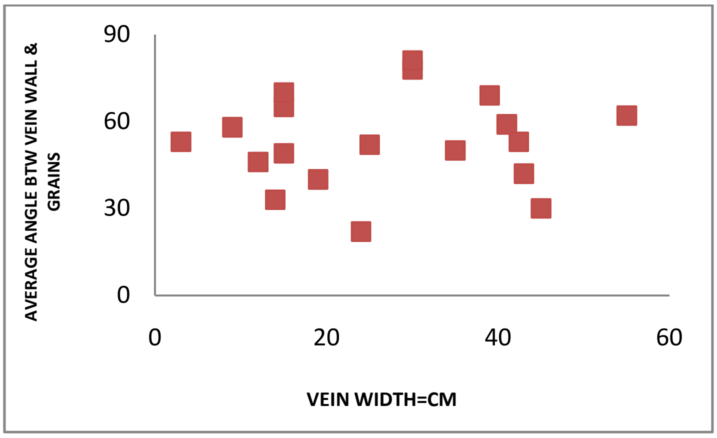


Fig.10: increase in vein width has no effect on the angle difference between the vein wall and long axis of megacrysts

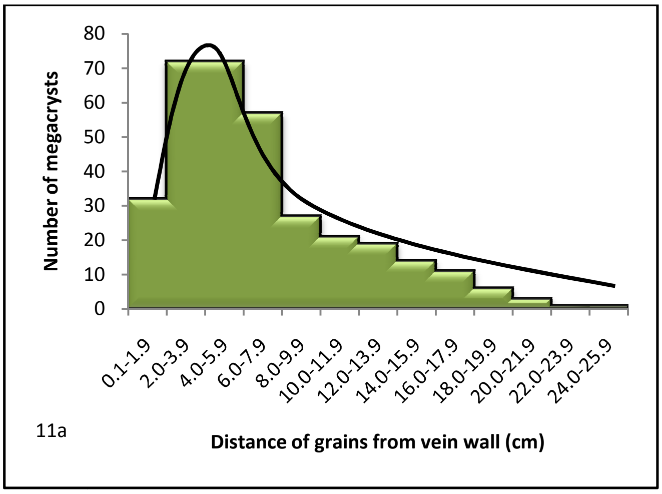
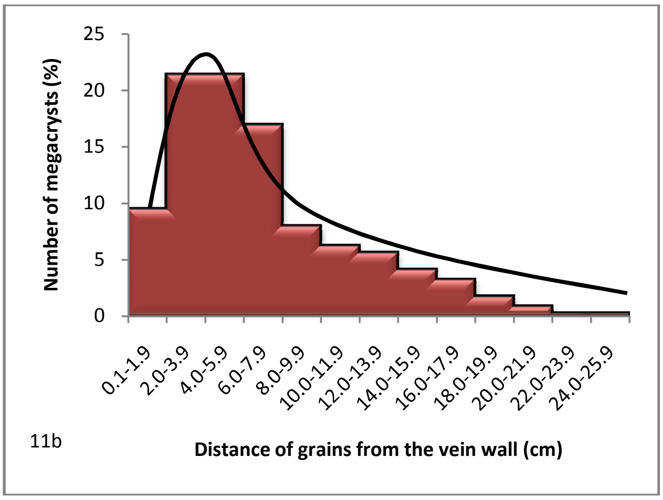


Fig. 11a and 11b: More megacrysts are found occurring closer to the vein wall than at the middle of vein



DISCUSSION

Since crystals grow and elongate perpendicular to the direction of maximum stress, the megacrysts in the pegmatite vein all ought to be aligned parallel to the vein wall. But this is not so in the veins. The plot of angles between the vein wall and long axis of megacrysts against the length of grains (Fig. 9), shows that the smaller (in length) grains have larger angle difference while the longer grains have lower angle difference. This shows that crystal sizes (length) play a role in the degree of rotation of the grains in the melt during flow. It is proposed that as the melt flows with formed megacrysts, the smaller grains are readily rotated, while the longer grains show some sign of resistance to the melt rotating force and therefore better aligned with the vein walls. No correlation was found between the average angle between the vein wall and the central lines of crystals and the vein width (fig. 10). It was initially expected that as vein width increases, it allows more space for the grains to grow and rotate and thereby causing the larger megacrysts to have a wider angle between their central line and the vein wall. but this is not the case. Maybe the thickness, hence viscosity has a role in this (as this may affect the flow rate and therefore the ability of the forming crystals to rotate).

There is a corresponding increase in the length of megacrysts as the distance between the vein wall and the central line of megacrysts increases (fig 8a and 8b). This means that the larger grains are further away from the vein wall (closer to the middle of the vein), while the smaller grains are closer to the vein wall. It is believed that since the melt loses its internal heat faster nearer to the vein wall (by convection and conduction), there is less time for crystals there to develop to large sizes, compared to crystals in the middle of the vein that had nucleated earlier and had enough time (due to slow cooling rate) to grow to large sizes.

An attempt is made to show how the frequency of megacrysts varies with increasing distance from the vein wall (Figs. 11a and 11b). It is observed that more grains occur very close to the vein wall than at the middle of the vein. Again if the relationship between the megacrysts sizes and the pegmatite vein width was deduced (Figs. 4a-4b and 5a-5b), it is observed that the wider the vein, the bigger (longer and wider) the megacrysts are and also the fewer the grains. That is, wider pegmatite veins have bigger but fewer megacrysts, while the smaller pegmatite veins have smaller but more megacrysts in them. The following generalisations are possible from the observations listed above: (1) the rate of cooling is not the same across a pegmatite vein. It is higher at the vein walls than in the core of the vein, for reasons of heat transfer and related phenomena of nucleation and grain growth; (2) wider pegmatite veins only provide more room for grains to enlarge, not to nucleate; (3) grain size and grain number seem to be the parameters that are traded as the width of a pegmatite vein changes; (4) since grain size depends on the location of a grain in a vein as well as the width of the vein, there is therefore no equilibrium grain size for a particular environment, like gneissose, schistose or other environments. Rather the variations of grain size with vein width (figs. 6a and 7a) should be sensitive to the host environment. According to [9], measurement of the frequency of crystal sizes provides a record of the nucleation and crystal growth history of an igneous rock. Therefore the most likely reason for all these observation in the megacrysts could be traced to the nucleation and crystal growth history of the rock, which is based on some nucleation and crystal growth theories [10]; [11]; [12]; [13], that: grain size is dictated by integrated number of nuclei forming per unit volume relative to the crystal growth rate – high nuclei population will yeild finer-grain crystals; rates of nucleation and crystal growth increase with undercooling below the freezing temperature of the crystal, come to a maximum, and then decrease; the rate of crystal growth depends on how fast particles can attatch to the growing crystal face or upon how fast latent heat of crystalization can be dissipated from the face. For better understanding, the graphs in the study were compared with results of [9] and it is clear that for very small degrees of undercooling, there is little or no probability of forming nuclei, but the few that succed in forming, eventually grow to large sizes because of a fairly high rate of crystal growth at this stage. But in the case where the change in temperature is high (or moderate undercooling), the nucleation rate becomes greater and the rate of crystal growth is also greater. So there is a tendency for more crystals to form and grow. But because these forming crystals compete for space and solute particles, the final grain size is usually less than in the first phase of undercooling. And this results in finer crystal grains which most likey explains why the bigger megacrysts in this study are fewer in frequency and the smaller grains are more in number.

CONLUSION

The larger megacrysts, which are also less frequently occurring, are most likely to be crystals that nucleated and started growing during a small degree of temperature change (during the cooling of the magmatic melt). And under favourable conditions they grew to large sizes. But the smaller-sized megacrysts, which are more in number, nucleated and grew during a greater degree of temperature change. Since under such conditions nucleation and growth rates were high, with the crystals competing for solute particles, more but smaller sizes of megacrysts were formed. This study has been able to show that indeed, the megacryst sizes (length and width) can be used to unravel the nucleation and crystal growth history of rocks. The results from this study agree well with similar studies done in other parts of the world ([14]; [4]; [15] [16].

Reccommedation

It is suggested that similar work is carried out in other host rock type like schists, granites and others, to compare using the slopes of the graphs (as in figs. 6a and 7a) any similarity or disparity in megacrysts behaviour.

REFERENCES

[1] E.E. Igonor, M.I. Oden, and E.E. Ukwang, Geochemical evaluation of basement rocks within Igbofia-uyanga-Iwuru area, SE Nigeria. 46th Annu. Conf. Nig. Min. Geosci. Soc., **2010**, Calabar, Nigeria, abstract, 9

[2] B.N. Ekwueme, and S.J. Ekwere, *Journ. Min. Geol*., **1989**, 25(1&2), 317-329.

[3] B.N. Ekwueme, and T.N. Nganje, *Global Journ. Pure and Applied Sci*., **2000**, 6 (2), 249-253.

[4] E. Dowty, In: Physics of magmatic Processes, R.B Hargraves (ed.), Crystal growth and nucleation theory and the numerical simulation of igneous crystallization (Princeton Univ. Press, NewJersey, 1980) 585.

[5] A.M.S. Rahman, E.E. Ukpong, and M. Azmatullah, *Journ. Min. Geol.*, **1981**, 18(11), 60-65.

[6] A.M.S. Rahman, S.J. Ekwere, M. Azmatullah, and E.E. Ukpong, *Journ. African Earth Science*, **1988**, 7, 149-159.

[7] B.N. Ekwueme, and C. Schlag, Compositions of monazites in pegmatites and related rocks of Oban Massif, southeast Nigeria: Implications for economic mineral exploration. International Geological Correlation Programme. **1989**, No. 255 Newsletter/bulletin, 2, 15-20.

[8] B.N. Ekwueme, *Journ. Min. Geol*. **1990d**, 26 (1), 69-74.

[9] M.G. Best, Igneous and metamorphic petrology. CBS Publ. New Delhi. **1986**.

[10] A. Holden, and P. Singer, Crystals and Crystal growing. New York: Anchor, **1960**.
[11] R. Bartlett, *American Journ. Science*, **1969**, 267, 1067 – 1082.
[12] J.C. Jaeger, In: Basalts; H.H.Hess and A. Poldervaart (Eds.), Cooling and solidification of igneous rocks (Wiley Interscience, New York, **1968**) 503 – 536.
[13] G.E. Lofgren, *American Journ. Science*, **1974**, 274, 243 – 273.
[14] G. Lofgren, In: Physics of magmatic Processes, R.B Hargraves (Ed.), Experimental studies on the dynamic crystallization of silicate melts (Princeton Univ. Press, NewJersey, **1980**) 585.
[15] E. Dowty, *Ammerican Mineral*. **1976a**, 61, 460 – 469.
[16] P.M. Fenn, *Can. Mineral*., **1977**, 13, 293 – 297.