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KYANITE IN THE HERCYNIAN METAMORPHIC ROCKS OF THE OPORTO-VISEU BELT, NORTH PORTUGAL

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ABSTRACT

Kyanite and garnet have been found in some metamorphosed rocks of the so-called low-pressure Oporto-Viseu belt of the Older Hercynian granites, Portugal. Reassessment of the nature of the metamorphism is therefore necessary, as well as its relation to the higher-pressure, Barrovian metamorphic belt to the west (Oliveira de Azemeis).

INTRODUCTION

Two main belts of regional metamorphism have been described south and south-east of Oporto (O e n 1970). The most westerly belt runs south-south-east through Oliveira de Azeneis to Albergaria a Velha and is characterised by schists and gneisses carrying staurolite, sillimanite, garnet and kyanite. This is regional metamorphism of Barrovian (higher pressure) type and is of uncertain age (O e n, ibid.). To the east, the Oporto-Viseu belt is spatially associated with the older Hercynian granites and shows the following zones:- sillimanite, andalusite-staurolite, biotite-chlorite. These "plutonometamorphic" zones were previously described as lacking garnet or kyanite and according to Oen (ibid.) represent a lower pressure facies series of the non-almandinous Abukuma or Buchan type of regional metamorphism. In the intermediate area near Oliveira de Azemeis, kyanite-bearing garnet-staurolite schists occasionally contain andalusite and sillimanite. Acoording to Oen (ibid.) such rocks are presumably polymetamorphic, with the "Abukuma" metamorphism transgressing the Barrovian metamorphism.

We were particularly interested in the relations between the two belts of metamorphism and what happened when these two belts joined. Our initial work took us to the Viseu region to look at the lower pressure belt, where examination of the staurolite schists near Cavernais (Oen 1958) revealed the presence of kyanite.

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PETROLOGY

Megacrysts of kyanite were found in veins or sweat-outs on the top of a small knoll northwest of the village of Cavernais. It was also found commonly as loose small fragments on a track running east of the knoll, and also in an erratic block found to the north of the village. The rocks in this area are highly altered, deeply weathered staurolite schists, with biotite and muscovite, ore and little or no feldspar. For a detailed description of the non-kyanite containing rocks, see O e n (1958).

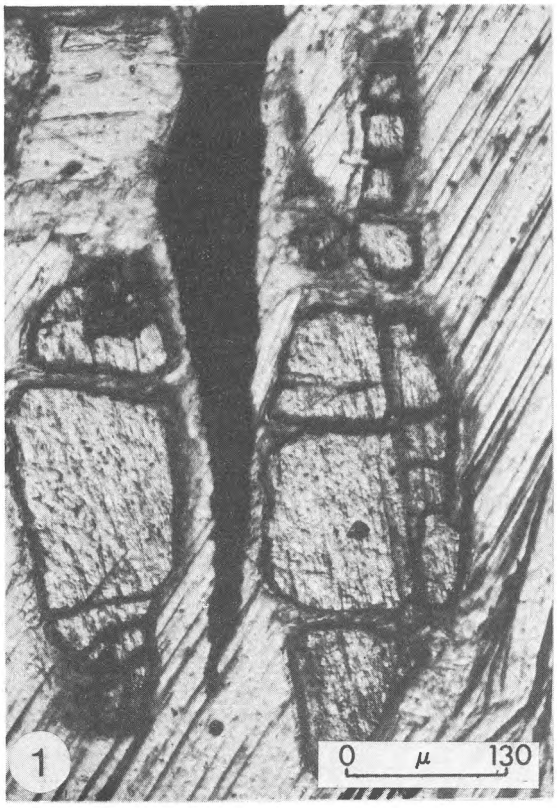
Description of the kyanite-bearing rocks

The kyanite in the coarse "vein" material is twinned with occasional development of kink-bands presumably caused by the late crenulation cleavage which is readily seen in hand specimen. On the other hand the kyanite schists consist of quartz, muscovite, biotite, staurolite, kyanite, andalusite, chlorite, shimmer aggregates and little or no feldspar. Common accessories include tourmaline, apatite and ore.

The major bulk of biotite is either decolourized to white mica or replaced by chlorite with which it is intergrown. Muscovite is common as bands consisting of oriented muscovite flakes and together with biotite and/or chloritized biotite they impart the schistose character of the rock. Late muscovite is evident as porphyroblasts of random orientation overprinting and cutting across the schistosity of the rock or else as flakes of coarsened shimmer enclosing remnants of kyanite (Plate 1-1) and staurolite. The enclosed kyanite is usually surrounded by a thin layer of shimmer.

Staurolite and kyanite occur as porphyroblasts containing inclusions of quartz and mica which are finer than those in the groundmass. Neither kyanite nor staurolite include one another; sometimes a relatively small grain of staurolite shares part of a crystal face of a growing kyanite – both minerals being optically continuous (Plate 1-2). Both kyanite and staurolite are partly or completely shimmered to fine sericite, remnants of the two minerals form small islands within the shimmer aggregates.

Andalusite porphyroblasts in these rocks grow from the shimmer aggregates-after-staurolite and/or kyanite. Occa-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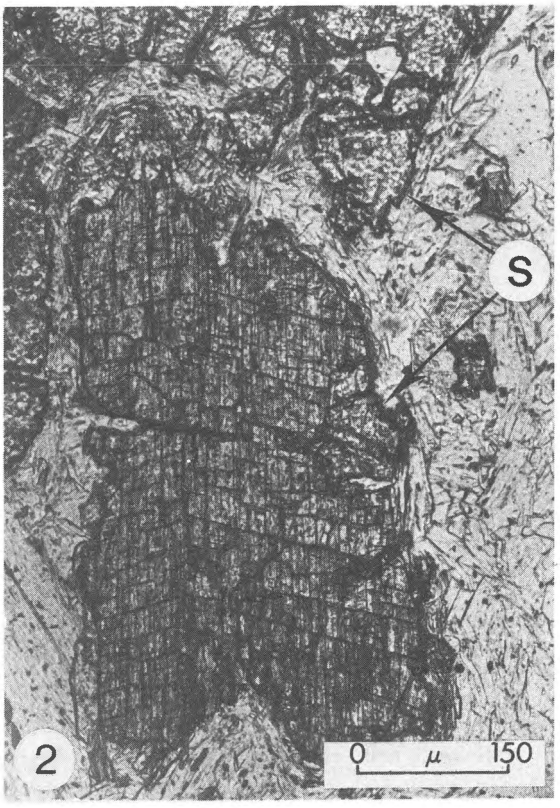
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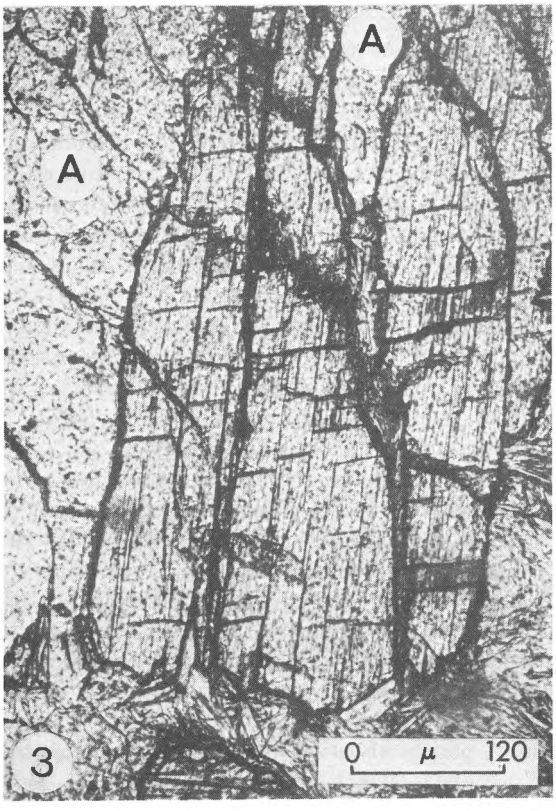
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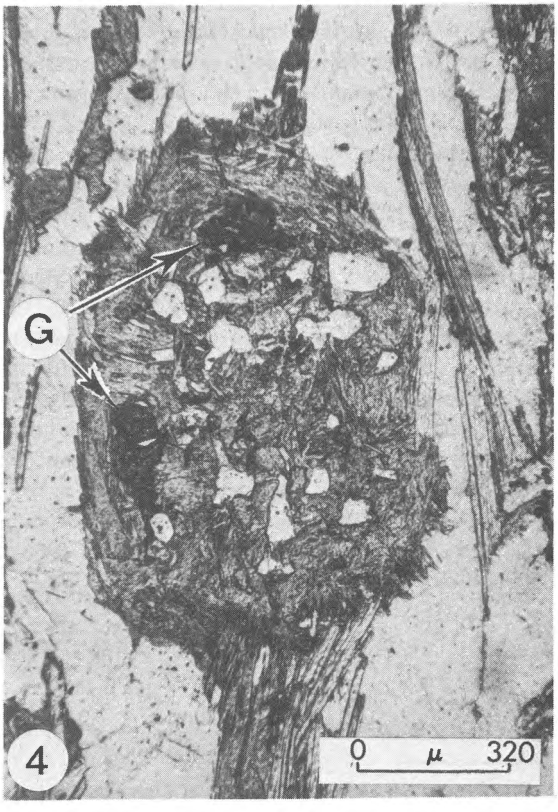
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sionally, andalusite includes remnants of staurolite and/or kyanite but never the reverse (Plate 1-3). No evidence of direct polymorphic transformation of kyanite to andalusite is seen and it is evident that andalusite is later than both kyanite and staurolite. There is no evidence that these minerals belong to a different episode of metamorphism, we follow O e n (1958) in putting staurolite and andalusite together in the same metamorphism, and as kyanite is coeval with staurolite, it too must belong to the same metamorphism.

In one of the finer grained rocks from the same locality, there is remnant garnet in chlorite pseudomorphs (Plate 1-4). Notably this rock is more siliceous and finer grained than the staurolite-rich rocks. In these finer grained rocks staurolite and kyanite occur together in sericitized patches and again are clearly coeval, and staurolite exceeds kyanite in amount.

DISCUSSION

The following comments on the general setting of the "plutonometamorphic" zones – taken from O e n (1958) – should be made before discussing the implications. *Firstly*, in general the metamorphism is associated with a deformation which produces large scale harmoneous bodies with concordant contracts, though not at Cavernais (Oen, ibid). The internal foliation in the granites is conformable with the schistosity in the neighbouring schists. *Secondly* index minerals can rarely be recognized in the field, except at Cavernais and Candal. Here as elsewhere, strong deformation and sericitization have markedly altered the rocks. *Thirdly*, the rocks with index minerals are frequently associated with low grade looking chlorite-sericite-biotite schists. *Fourthly*, andalusite occurs rarely with staurolite which it appears to postdate, and both are earlier than coarse or recrystallised sillimanite. *Fifthly*, staurolite-bearing schists are limited to the regions near Vouzela and Cavernais, where it may exceed 2 cm in size. Frequently, according to Oen (ibid.) biotite is absent in staurolite rocks. *Sixthly*, the younger granite thermal metamorphism produces cordierite and chiastolite in the Beira schists. *Seventhly*, garnet was found in only two sillimanite grade schists.

In brief O e n (1958, 1970) was particularly impressed by the absence of kyanite and the paucity of garnet, and it was this plus the presence of andalusite which led him to postulate a low pressure "plutonometamorphism". Clearly, from the data outlined above there are some gross problems still unsettled with regard to the metamorphism, why for instance are andalusite and staurolite apparently invompatible? And why are the metamorphic index minerals unevenly developed both within adjacent schists and in different parts of the "aureole"? These and other questions must remain unanswered for the moment, but it is clear that the metamorphism is of some complexity, and in this context our findings may be important in understanding the situation better.

Most importantly, our find of kyanite in 3 out of 8 rocks sectioned from Cavernais, shows that kyanite may well be an important mineral in the rocks of the "aureole". It also shows that the conclusion with regard to the low pressure metamorphism as defined by the absence of kyanite is no longer tenable. The lack of large amounts of kyanite may well be due to compositional and/or heating control (N a g g a r and A t h e r t o n 1970). With regard to garnet the situation is more diffucult to define. We found garnet in one of the schists, notably a more siliceous rock, much less coarsely recrystallized than the typical staurolite schists. O e n (1958) eliminated the possibility of an unsuitable rock composition on the grounds that the Mg/Fe ratio was suitable (cf. the occurrence of staurolite) and that the Mn is not a controlling factor as spessartite-free almandine garnet occurs in normal amphibolite facies rocks. We have no real means of deciding this question as there are no analyses of the Beira Schists, however the staurolite rocks are odd in so far as biotite is absent as a rule (O e n, 1958). Where biotite is present with staurolite it is quite possible that this two-phase assemblage, without garnet may represent an equilibrium assemblage. Until data are forthcoming we would be prepared to accept some compositional control as a possibility. Whether the latter is true or not, the presence of garnet in one of our samples, compositionally different to the staurolite rich rocks at least leaves the question open. In spite of the caveat above, the presence of garnet and kyanite in our limited number of samples leads us to suspect their presence elsewhere throughout the Oporto-Viseu belt.

Having pointed out that the presence of kyanite needs a reassessment of the type of metamorphism of the Oporto-Viseu belt, we would like to comment on its relation to the Oporto-Albergaria a Velha belt of Barrovian metamorphism. Along the "junction" of these two belts are schists containing andalusite and kyanite (O e n 1970), particularly at Oliveira de Azemeis and to the east of Oporto (personal communication, Professor Montenegro). These schists are not common but we have as yet no information suggesting that the metamorphism producing these schists is of a different age to that at Cavernais. In fact very little evidence is available as far as we have been able to ascertain with regard to the presence of kyanite in the whole of the Oporto-Albergaria a Velha belt. In the two references quoted by O e n (1970), namely S o u z a B r a n d a o (1914) and P i n t o de M e s q u i t a (1952) we could find no mention of kyanite assemblages. In view of the above rather limited findings we

Fig. 1
Late muscovite plates enclosing partly corroded kyanite. The kyanite is surrounded by a very thin layer of shimmer.

Fig. 2
Kyanite and staurolite (S), partly shimmered showing coeval crystallization.

Fig. 3
Andalusite (A) including kyanite.

Fig. 4
Chlorite pseudomorphing garnet, of which a few remnants persist (G).

therefore conclude that there is no reason yet to postulate an overprint of the Abukuma metamorphism on the Barrovian metamorphism; for the time relations could well be similar to those at Cavernais where the early staurolite plus kyanite is followed in the same metamorphism by andalusite and finally by sillimanite. Such sequences, kyanite: andalusite: sillimanite have been noted elsewhere in similar terrains such as Donegal, Eire (N a g g a r and A t h e r t o n 1970) where the aluminium silicates have developed in rocks of similar mineralogy, i.e. chlorite-biotite-muscovite. Indeed there is a further similarity between these two areas in that chloritoid is formed during a later stage, possibly a cooling stage in the metamorphism (N a g g a r and A t h e r t o n 1970, A t h e r t o n in press).

In conclusion much work needs to be done to lend more certainty to the suggestions above, but any future analysis will certainly have to account for the presence of kyanite and garnet in the rocks from Cavernais.

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REFERENCES

Atherton, M.P. (1973) – The occurrence and implications of chloritoid in a contact aureole andalusite schist from Ardara, Co. Donegal, Eire. In press.

Brandao, V. Souza (1914) – A faixa occidental das phyllites porphyroblasticas no Precambrico do distrito de Aveiro. Comm. Serv. Geol. Portugal, vol. 10, pp. 78-142.

Naggar, M.H., & M.P. Atherton (1970) – The composition and metamorphic history of some aluminium silicates bearing rocks from the aureoles of the Donegal granites.
Jour. Petrology, vol. 11, pp. 549-589.

Oen, I.S. (1958) – The geology, petrology and ore deposits of the Viseu region, Northern Portugal.
Com. Serv. Geol. Portugal, vol. 41, 179 p.
(1970) – Granite intrusion, folding and metamorphism in central northern Portugal.
Bol. Geol. y Minero, vol 81, pp. 157-184.

Pinto de Mesquita, L. (1952) – Contribuicao para o estudo de parte da faixa metamorfica de litoral, a sul de Espinho.
Publ. Museu e Lab. Min. Geol. Fac. Cienc. Porto, num. 63, 3ª ser., 28 p.