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# PETROLOGY OF THE TEIJEIRO AREA: PART OF THE EARLY PALAEOZOIC HIGH-GRADE METAMORPHIC SOBRADO/TEIJEIRO COMPLEX (GALICIA, NW SPAIN)

BY

R. P. KUIJPER*

## ABSTRACT

The high-grade metamorphic Sobrado-Teijeiro complex forms part of the peripheral belt of the Ordenes basin. The fault-bounded elliptical complex consists of a central unit of highly serpentinized ultramafic rocks, surrounded by (partly retrograded) mafic granulite facies rocks, high-grade paragneisses and orthogneisses.

The area studied comprises the northern part of the complex. Here the ultramafic rocks are almost completely serpentinized and only in a few specimens relics of olivine, clinopyroxene, orthopyroxene and amphibole have been found. Paragneisses, consisting of K-feldspar, plagioclase, quartz, biotite, muscovite and garnet, form a rim around the mafic and ultramafic rocks. Coarse-grained orthogneisses, belonging to two different bodies, form the outermost parts of the complex. Mafic rocks occur in between the serpentinites and the paragneisses.

Several phases of metamorphism and deformation can be discerned. A first phase of metamorphism under conditions of the clinopyroxene-almandine subfacies gave rise to a granoblastic-polygonal fabric consisting of rather jadeite-rich clinopyroxene, garnet and plagioclase. During a second phase of metamorphism, preceded and accompanied by deformation, recrystallization of the original assemblage and growth of brown hornblende at the expense of clinopyroxene occurred, giving rise to blastomylonitic and granulitic textures. Further retrogradations took place under amphibolite and greenschist facies conditions. This sequence of events resulted in a rather heterogeneous unit, ranging from essentially non-altered granofelses, via blastomylonites to amphibolites and greenschists in which hardly any relics of high-grade minerals are encountered.

## INTRODUCTION

West-Galicia (NW Spain) consists of abundant masses of Lower Palaeozoic granites and migmatites and minor amounts of metasediments, surrounding a number of polymetamorphic complexes. These complexes (Fig. 1) consist of varying amounts of high-grade metamorphic mafic and ultramafic rocks, metasediments and orthogneisses. Originally it was thought that the complicated metamorphic and structural history, visible in the complexes, was mainly due to a Precambrian orogenic event, while the Variscan orogeny, although resulting in large-scale granite intrusion and folding, metamorphism and migmatization of the Lower Palaeozoic sediments, was only responsible for the last phases of retrogradation and folding in the older complexes (Engels et al., 1972; Den Tex & Floor, 1971). However, geochronological investigations have shown that the high-grade metamorphism and the emplacement of ultramafics took place in Early Palaeozoic times, with hardly any time-gap between the second phase of granulite facies metamorphism (350 Ma) and the intrusion of the oldest Variscan granites (320–315 Ma) (van Calsteren et al., 1979).

## GEOLOGICAL SETTING

The area under discussion comprises the northern part of the high-grade metamorphic Sobrado/Teijeiro complex and its surrounding rocks, situated in the eastern rim of the metasedimentary Ordenes basin, north of the comparable Mellid complex (Hubregtse, 1973). Both complexes consist of a central unit of partly serpentinized peridotites, surrounded by mafic granulite facies rocks and high-grade metamorphic paragneisses. Coarse-grained augengneisses separate the complexes from each other and from the lower-grade metasediments of the Ordenes basin. Nearly all contacts between adjacent rock units are faulted. From gravity data it is apparent that both complexes contain a deep-rooted core of high-density rocks (Keasberry et al., 1976).

## LOW-GRADE METAMORPHIC ROCKS

*Espenuca granite*

The Espenuca granite (Fig. 2) in the north is a medium- to coarse-grained two-mica granite with a variable amount of alkali-feldspar phenocrysts and biotite, containing accessory apatite, zircon, garnet and sphene. Judged from its plagioclase composition (15–35% An) it belongs to the calc-alkaline series delineated by Floor (1970). At the margins of the body a very weak mica foliation and undulatory extinction of most minerals occur. The local alignment of feldspar phenocrysts is probably related to flow during emplacement. Comparable largely post-kinematic granites have yielded ages of around 290 Ma (Priem et al., 1970). Contact metamorphic effects of the Espenuca granite have only been found north of the area (Keasberry, 1975) and possibly in the Teijeiro metagabbro (see below). A large aplite vein, probably related to the Espenuca granite, crosscuts both the metagabbro and the adjacent orthogneisses.

*Coba de Serpe granites*

The Coba de Serpe granites (Fig. 2) east of the complex form part of a narrow, meridional trending belt of granites, extending from near Palas del Rey in the south to west of Cedeira in the north. Granites of both the calc-alkaline and the alkaline series (Floor, 1970), intermingled in a rather insystematic way, intruded before and were gneissified during the last major deformation phase. Emplacement of these

*) Dr. René P. Kuijper, c/o Nirwanaflat 21, Benoordenhoutseweg 227, 2596 BJ Den Haag, The Netherlands.

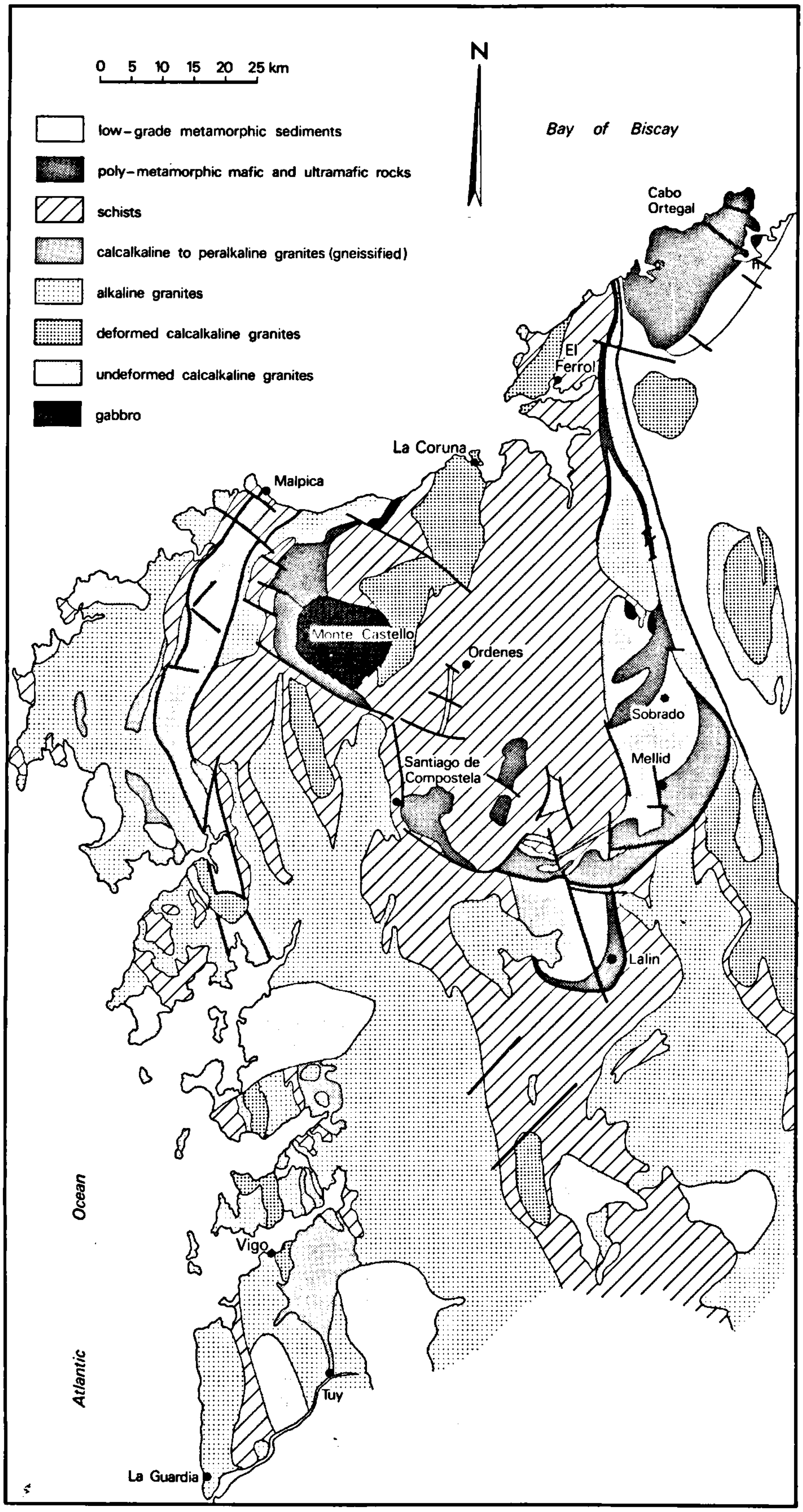


Fig. 1. Simplified geological map of Western Galicia.

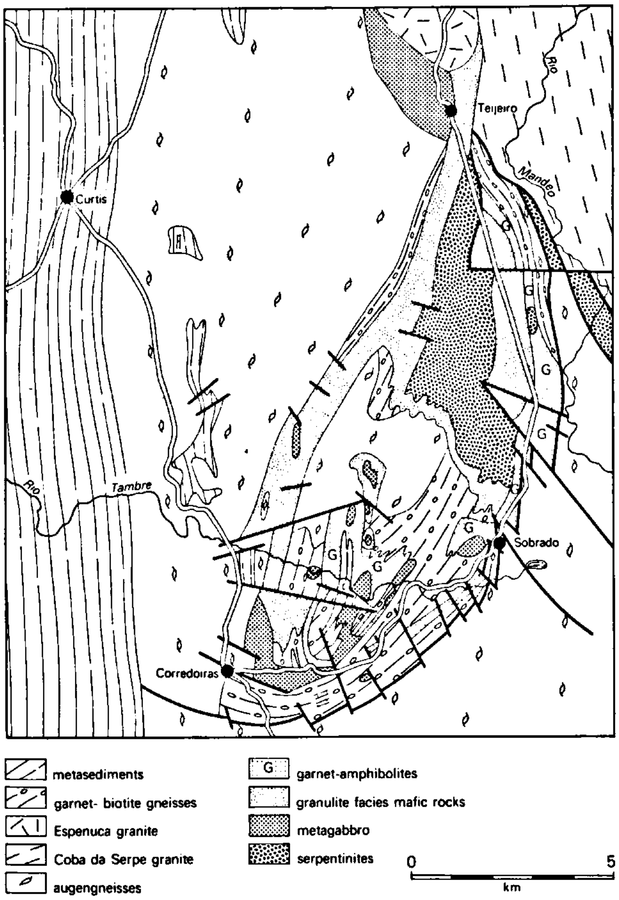


Fig. 2. Simplified geological map of the Sobrado/Teijeiro complex.

granites was probably facilitated by the major fault separating west from east Galicia. Zircon, apatite, sphene, tourmaline and garnet are accessories in both granites. Development of the foliation took place under upper-greenschist to lower amphibolite facies conditions, as can be inferred from the mineral-assemblage (blue-green hornblende + actinolite + oligoclase + sphene) in mafic dikes. Locally a very weak folding of the main foliation is visible. Gneissified granites in other parts of Galicia have revealed ages of around 310 Ma (van Calsteren et al., 1979).

*Ordenes metasediments*

The Ordenes metasediments (Fig. 2) in the western part of the area are fine-grained to microcrystalline schists and phyllites, composed of biotite, muscovite, quartz and plagioclase (15–30 % An) with minor garnet and locally K-feldspar. Zircon, tourmaline and apatite occur as accessories. In the narrow zone between the Espenuca granite and the orthogneisses, the schists are fine-grained, laminated and richer in garnet. Mafic rocks occur as foliated dikes and lenses parallel to the foliation near the contact with the orthogneisses. Plagioclase (10–20 % An), common to actinolitic hornblende and locally quartz are the main constituents, biotite and locally garnet are minor components, while apatite, sphene, zircon and clinozoisite occur as accessories. The vertical main foliation was developed under conditions of the upper-greenschist to lower amphibolite facies. In the schists biotite and muscovite intensively recrystallized, while garnet growth was largely pre-kinematic with respect to the main foliation. During a phase of retrogradation it was replaced by aggregates of unoriented biotite ± muscovite ± chlorite, while randomly oriented chlorite and muscovite developed at the expense of oriented micas. A final deformation phase resulted in undulatory extinction of micas, kinking of new chlorite and a disturbance of the main foliation, which only locally shows chevron-type folding. Pre-kinematic relics of biotite and muscovite clasts in mica-rich layers are the oldest recognizable fabric elements. The increase in metamorphic grade from west to east, which has been found in the schists near Mellid (Hubregtse, 1973) is not obvious in the Teijeiro area. Only the slight increase in amount of garnet and the decrease in grossular and increase in pyrope content from west to east could possibly be related to such a change in metamorphic conditions.

*Augengneisses*

The orthogneisses west of the high-grade metamorphic complex are coarse-grained biotite-rich augengneisses (Fig. 2) with a varying amount of feldspar-phenoclasts. Deformation varies, not only on a large scale, increasing from north to south (in the north the rocks are moderately deformed bi-granites) but also on a small scale in the stronger deformed southern parts where the foliation varies from a strong feldspar orientation to a real foliation plane of parallel micas in planar to planolinear augengneisses. In the field the occurrence of – sometimes strongly – blue-coloured quartz grains is a conspicuous feature. Foliated pegmaplite veins occur throughout the area. K-feldspar, plagioclase (20–30 % An), quartz and biotite are the main constituents of the gneisses, muscovite is a minor component; garnet, sphene, apatite, zircon, rutile, tourmaline, epidote/clinozoisite and allanite occur as accessories. Locally occur small xenoliths of schists and mafic rocks, comparable to those in the Ordenes schists and containing small poikiloblasts of common hornblende and garnet. During development of the main foliation, which took place under amphibolite facies conditions, small biotite-flakes were concentrated in layers enveloping large kinked biotite-clasts, granulated feldspar-phenoclasts and garnet-grains. Later retrogradation resulted in biotite ± chlorite ± muscovite aggregates pseudomorphic after garnet and minor recrystallization of granulated feldspar rims. Undulatory extinction of the youngest micas is due to the last deformation phase. Because of the poor exposure it is difficult to assess the nature of the contacts with the surrounding rock units. Only along the railroad near Curtis (Fig. 2) some probable intrusive relationships with the Ordenes schists are visible. The contacts with the high-grade unit are most probably faulted.

East of the high-grade metamorphic rocks occurs a narrow zone of comparable orthogneisses, which broadens to the south and is part of the Mellid complex (Hubregtse, 1973). In contrast to the gneisses in the west, a foliation older than the main one, which in these rocks was also developed under amphibolite facies conditions, is visible. The contact with the paragneisses is faulted, as can be inferred from the occurrence of strongly blastomylonitic fabrics in samples near the rim of the gneisses.

*Serpentinites*

Due to non-exposure in the valley of the Rio Mandeo, the serpentinites (Fig. 2) which occur as a zone together with epidote-amphibolites along the eastern rim of the Mellid complex and the Sobrado/Teijeiro complex to the south of the investigated area (Hubregtse, 1973; van Riessen, 1970) have only been found as a large amount of loose boulders. These rocks are completely serpentinized, consisting of antigorite and γ-serpentine with minor talc, chlorite and opaques.

*Metagabbro of Teijeiro*

The Teijeiro metagabbro (Fig. 2) is situated north of the high-grade metamorphic rocks. The most common rock-type in this body is a fine- to medium-grained metagabbro, consisting of plagioclase (50–80 % An) and hornblende, with chlorite, biotite, quartz, epidote/clinozoisite, tourmaline, prehnite, apatite, sphene and opaques occurring as accessories and products of retrogradation. Both pegmatoid as well as finer-grained parts, the latter in a few cases as narrow dikes or lenses, containing the same minerals as listed above, have been encountered. An ophitic texture is always clearly visible, while foliation or flaser texture are lacking. Near the eastern rim of the body some biotite-rich samples have been found, consisting of plagioclase (40–60 % An)- and polycrystalline quartz-augen in an ophitic matrix of plagioclase, quartz, biotite and amphibole. Accessory minerals in these rocks are zircon, tourmaline, apatite, garnet (strongly resorbed), allanite and K-feldspar-relics in large myrmekite aggregates. Although the field relationships are not visible, these rocks can probably be interpreted as contaminated country rocks, which were taken up as xenoliths during the intrusion. In view of the accessory minerals (zircon, allanite, apatite and garnet) a connection between the supposed contaminated xenoliths and the augen-gneisses to the west seems attractive, albeit highly speculative. Despite the lack of pyroxene-relics, the high anorthite content of the plagioclase and the occurrence of opaque inclusions (schiller) in a 90° pattern in amphibole renders a gabbroic source rock highly probable. A first metamorphic phase resulted in the total replacement of original pyroxene by a colourless to green hornblende. Small patches of brown hornblende are either primary magmatic or were formed contemporaneously with the common hornblende. Small veinlets containing prehnite and epidote were also developed during this phase. Later retrogradation under greenschist facies conditions resulted in the replacement of hornblende by actinolite aggregates (uralite), Mg-rich chlorite and minor biotite, while plagioclase was saussuritized. Narrow rims of actinolite + biotite formed around older biotite and hornblende in the contaminated rocks. In spite of the total adaption of the mafic minerals to the low-grade conditions, the anorthite content of the plagioclase remained high or very high in all samples. The occurrence of tourmaline enclosing actinolite and chlorite, of actinolite + chlorite-rims around chlorite-aggregates, and of recrystallized actinolite in dense uralite can possibly be attributed to influences of the bordering and clearly younger Espenuca granite.

## HIGH-GRADE METAMORPHIC ROCKS

The high-grade metamorphic part (Fig. 2) of the complex consists of a core of serpentinized peridotites, surrounded by mafic granulites and granofelses, paragneisses and amphibolites.

The central ultramafic rocks are almost completely serpentinized, consisting of antigorite, chlorite, minor grammatite, both γ and α-serpentine, carbonates and talc. Few relics of olivine (Fo 85–90), orthopyroxene, clinopyroxene, a pargasitic hornblende and a common hornblende were encountered. In some samples the olivine shows a perfect cleavage or parting in three crystallographic directions (Kuijper, 1979). A foliation formed by parallel orientation of serpentine and carbonate layers, chlorite-aggregates and opaques, is present in most samples. Only the occurrence of relics of olivine, orthopyroxene, clinopyroxene and pargasitic hornblende gives an indication for granulite facies conditions. The paragenesis grammatite + chlorite ± antigorite ± common hornblende points to adaption to amphibolite facies conditions. Under greenschist facies conditions, γ- and α-serpentine and carbonate replaced most of the older minerals. Talc is the youngest mineral formed. Talcschists are frequently met with along the periphery of the serpentinite body, indicating a fault-contact.

Two narrow zones of paragneisses are situated between the orthogneisses in the west and east and the central mafic and ultramafic rocks. These garnet-biotite-gneisses consist of K-feldspar, plagioclase (20–35 % An) and garnet-clasts in a groundmass of K-feldspar, plagioclase, quartz and biotite, with accessory sphene, zircon, apatite, tourmaline, rutile, α-zoisite and allanite (the latter two only in the eastern gneisses). Chlorite, epidote/clinozoisite and sericite are products of retrogradation. Muscovite is an accessory mineral in the western ga-bi-gneisses but forms a minor to major (up to 10 vol%) component in the eastern zone, where also the only sample with kyanite (15–20 vol%) has been found. The amount and size of K-feldspar clasts shows a gradual increase from west to east in the eastern ga-bi-gneisses, accompanied by decrease in biotite-content. A planar to planolinear texture, with K-feldspar and quartz often concentrated in small augen and streaks, is visible in all samples, while near the contacts with the orthogneisses blastomylonitic textures appear. Recrystallized mortar-rims around feldspar porphyroclasts indicate that blastomylonitization occurred before the greenschist facies retrogradation, while subsequent granulation of these rims shows that a phase of cataclastic deformation postdated the retrogradation. Apart from a few outcrops of (ga-) hornblende-gneiss, no mafic rocks occur in the western ga-bi-gneisses. In the eastern zone however mafic and ultramafic rocks are more widespread. A metadolerite dike without high-grade relics is situated near the eastern rim. Retrograded mafic granofelses occur as rounded inclusions (up to 1 m∅), wrapped around by the foliation of the gneisses. The probably secondary origin of the plagioclase in one of these occurrences, renders an eclogitic parent rock probable. In a small gabbroic intrusion, an ophitic texture and reaction rims of garnet between plagioclase and pyroxene are macroscopically visible (Fig. 3). Plagioclase (zoned with core 25–30 % An, rim 35–40 % An) – recrystallized into granoblastic

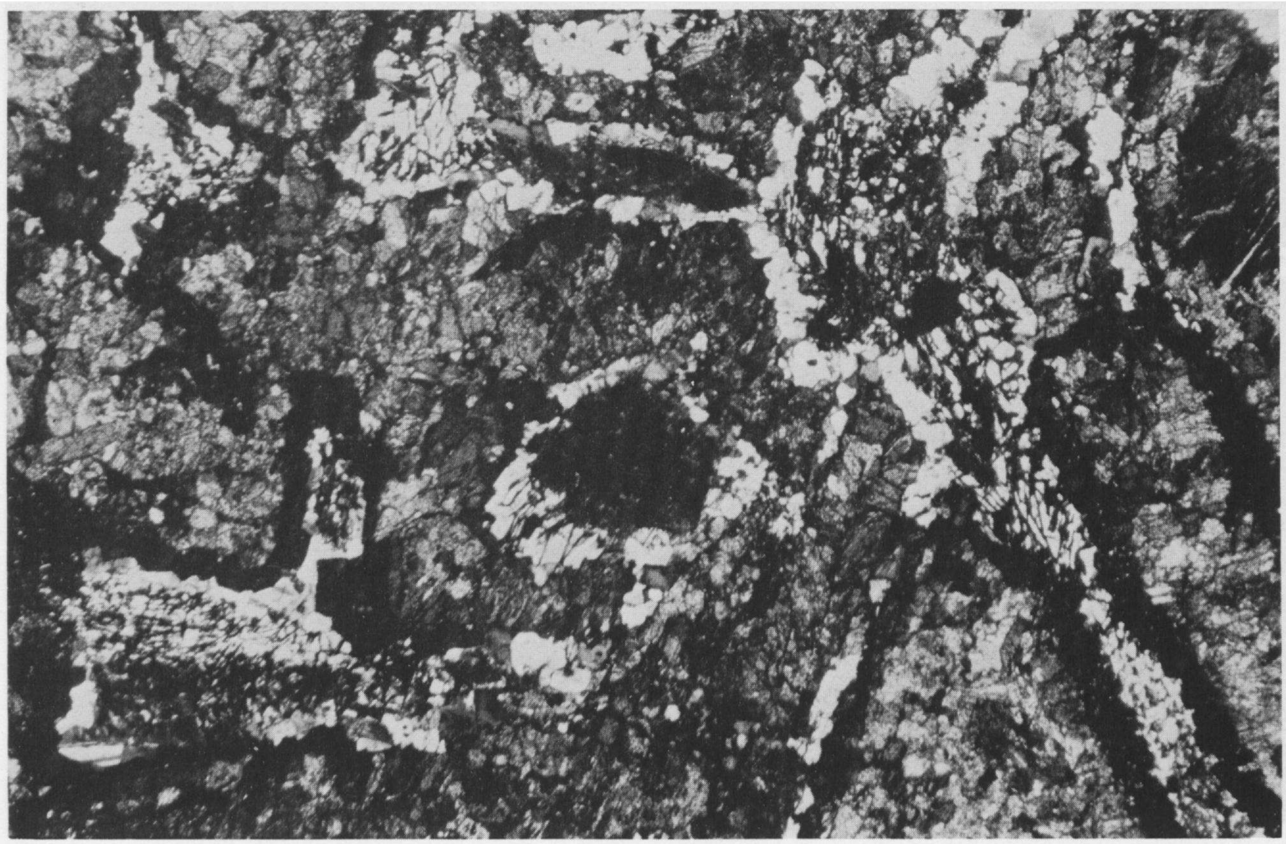

Fig. 3. Garnet-coronas around pyroxene/amphibole-aggregates. Field width 10 mm.

polygonal aggregates –, clinopyroxene (altered into a light brown pargasitic hornblende), garnet and common hornblende are the main constituents, while biotite, actinolite, chlorite, rutile and clinozoisite occur as accessories and further products of retrogradation. Similar gabbroic intrusions, with mineral assemblages indicating granulite facies metamorphism, occur in the southern part of the Sobrado/Teijeiro complex (van Riessen, 1970; van Overmeeren, 1970).

A narrow discontinuous band of fine-grained garnet-amphibolites, containing few relics of a probable high-grade metamorphic paragenesis, is situated along the contact of the eastern paragneisses and the mafic granulites. Two serpentinized ultramafic bodies occur in this band, only one of them contains relics of olivine (Fo 90), bronzite and pargasitic (?) hornblende.

Since the high-grade mafic rocks around the central serpentinites will be subject of a future paper, description of these rocks will be comparatively concise. They form a rather heterogeneous unit, consisting of granofelses, granulites, garnet-amphibolites, epidote-rich amphibolites, eclogites and metagabbros, in which most of the heterogeneity is due to different degree of retrogradation and deformation. Enclosed in this unit occur two outcrops of ga-bi-gneiss and ga-sericite-gneiss respectively. Rocks which largely survived later retrogradations lack any foliation or layering and consist of a granoblastic-polygonal assemblage of garnet, diopsidic clinopyroxene and plagioclase (25–45 % An) with minor brown hornblende and quartz (Fig. 4). Accordingly they are named (hbl)-ga-cpx-granofelses, formed during a first phase of metamorphism under conditions of the (hornblende)-clinopyroxene-almandine-subfacies of the granulite facies (de Waard, 1965). Rutile (often as small needles in garnet), $\alpha$- and $\beta$-zoisite and zircon occur as accessories, while small amounts of mizzonitic scapolite, blue-green hornblende, actinolite, chlorite, sphene and epidote/clinozoisite were produced during later phases of metamorphism. In a large number of samples a symplectic intergrowth of diopsidic clinopyroxene and plagioclase is visible, indicating the original existence of a rather jadeite-rich clinopyroxene. This, together with the occurrence of rutile-needles in garnet and kelyphitic amphibole-plagioclase rims around garnet could be regarded, like similar occurrences on Cabo Ortegal (Vogel, 1967), as indicating a transition between eclogite- and granulite facies assemblages.

During a subsequent phase under conditions of the hbl-cpx-alm-subfacies, $P_{H_2O}$ was slightly higher, possibly accompanied by a slightly lower P-total. This phase was preceded and accompanied by penetrative deformation, resulting in blastomylonitic textures (Fig. 5) and a banding on mm to cm scale. In the resulting mafic granulites a second generation of garnet formed (Fig. 5), clinopyroxene partly recrystallized while some brown hornblende formed at the expense of clinopyroxene. In a few instances, plag-cpx-symplectites re-

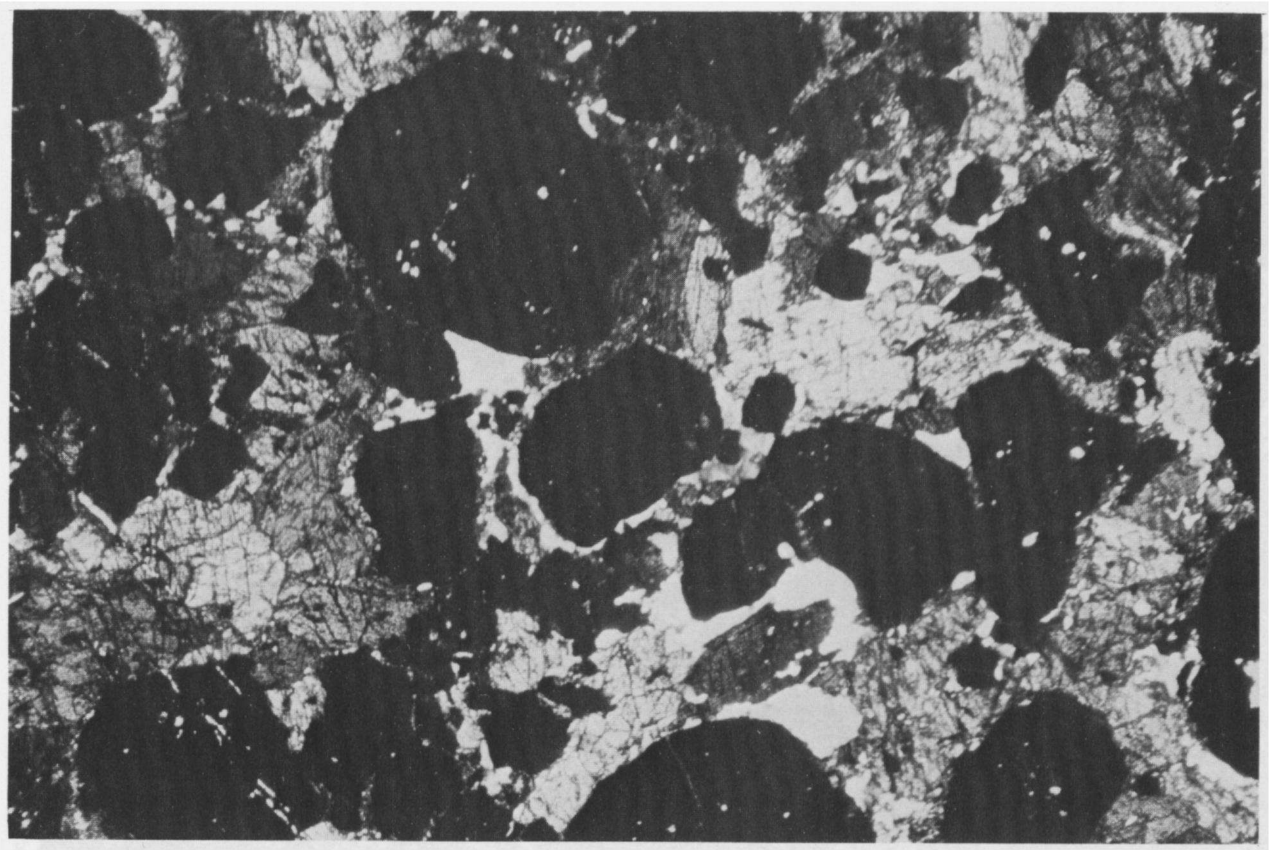

Fig. 4. Granoblastic-polygonal fabric of granofelses. Field width 10 mm.

Fig. 5. Blastomylonitic texture of granulites with second generation of garnet. Field width 10 mm.

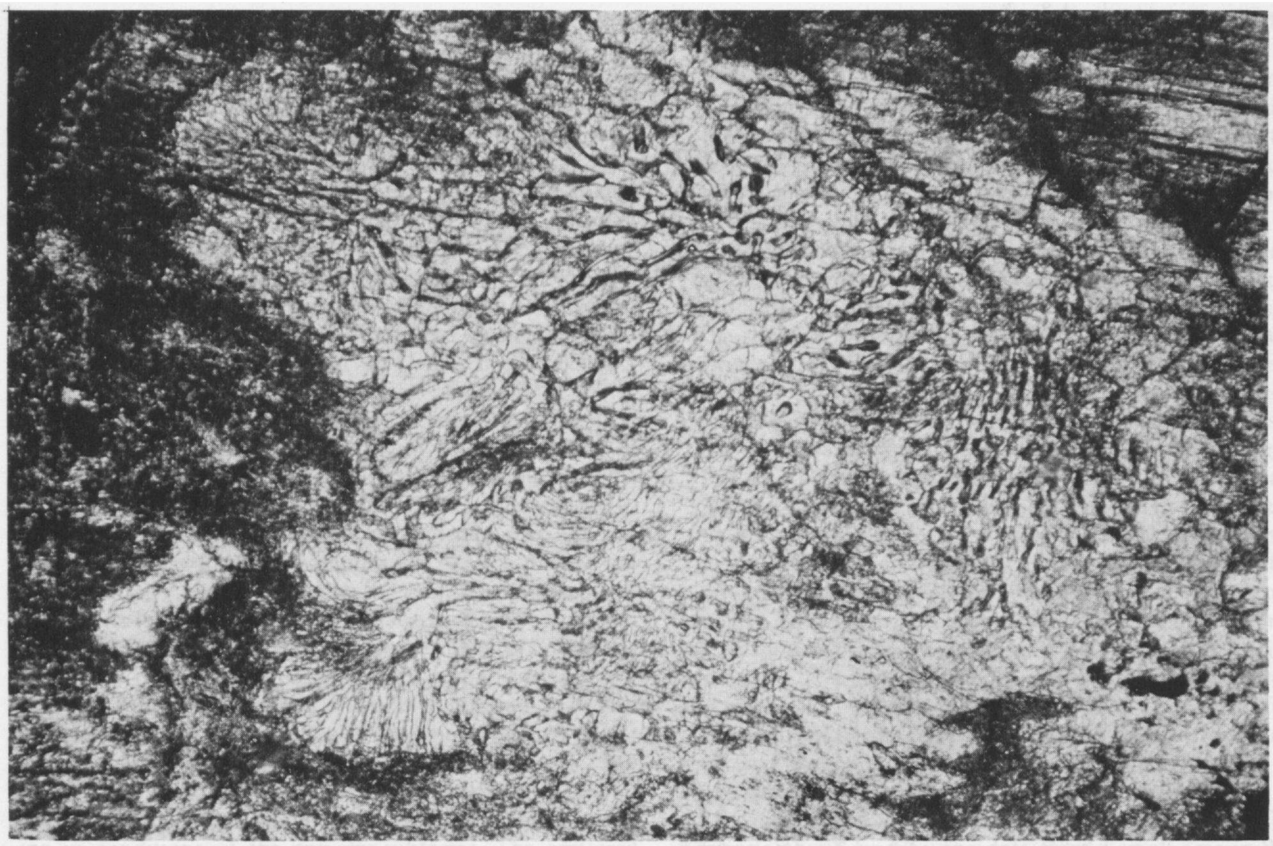

Fig. 6. Clinopyroxene-plagioclase-symplectite in eclogite. Field width 1.7 mm.

crystallized, giving rise to plagioclase blebs in diopsidic clinopyroxene and indicating that symplectites formed, at least partly, already during the first phase of granulite facies metamorphism. A very local migmatization in the mafic granulites took place during this phase. Amphibolite facies conditions reigned during a third phase of metamorphism, which was again accompanied by penetrative deformation, giving rise to blastomylonitic textures and the main foliation of the rocks. This retrogradation resulted locally in the formation of amphibolites and garnet-amphibolites in which only relics of the former high-grade parageneses are visible. Clinopyroxene and brown hornblende were replaced by (blue)-green hornblende, which sometimes formed symplectic intergrowths with plagioclase at the expense of clinopyroxene. Kelyphitic rims of hornblende and plagioclase formed around garnet, while narrow rims of sphene developed around rutile and opaques. Small veinlets filled with epidote/clinozoisite were also produced during this phase, to which the following paragenesis belongs: (blue)-green hornblende + plagioclase + sphene + epidote/clinozoisite + quartz ± garnet.

The final retrogradation took place under greenschist facies conditions during a fourth phase of metamorphism, this time without deformation. Most of the minerals formed during earlier phases were (at least partly) replaced by a new paragenesis of actinolite + blue-green hornblende + chlorite + (Fe-poor) epidote/clinozoisite + plagioclase + quartz. A final and minor deformation phase caused only undulatory extinction of most minerals.

Scattered throughout the unit occur some amphibolites rich in epidote-group minerals. Apart from relics of clinopyroxene, garnet and brown hornblende, indicating that these rocks underwent the same metamorphic history as the surrounding granulites, these rocks contain up to 25 vol % of $\beta$-zoisite, as xeno- to hypidiomorphic, short- and longprismatic grains, usually in large aggregates.

Gabbroic rocks, showing a relic ophitic texture, have been found in a few places. Like the metagabbro in the ga-bi-gneisses, they often show garnet-coronas around polycrystalline amphibole-clinopyroxene-aggregates. Penetrative deformation has given rise to flaser-textures in one of the gabbros. A 50 cm ∅ serpentinite ball occurs included near the western rim of the mafic granulites.

A relatively large amount of eclogite-occurrences has been found scattered throughout the mafic high-grade rocks east of the central serpentinites. Foliation is in some samples absent, others show blastomylonitic textures. Clinopyroxene and garnet are the main constituents, occurring as large porphyroblasts or -clasts, while $\alpha$-zoisite, quartz, kyanite and rutile occur as accessories. Most of the original jadeite-rich clinopyroxene is now present as cpx-plag-symplectites (Fig. 6), in a few cases surrounded and partly replaced by symplectites of brown hornblende + plagioclase, which also replace the clinopyroxene without cpx-plag-symplectites. Further retrogradation resulted in the development of brown and green hornblende, epidote/clinozoisite, chlorite, sphene and sericite (around kyanite).

| phase | age* | rock units of high-grade metamorphic unit | | | rock units of low-grade metamorphic unit | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | ultramafics | mafics | paragneisses | orthogneisses | Ordenes schists | Teijeiro metagabbro | Coba de Serpe granites | Espenuca granite intrusion |
| $F_5$ | | | undulatory extinction of $M_4$-minerals | | | | to + act + chl | | |
| | | | | local cataclasis | | local chevron folding | | | |
| $M_4$ | 290 Ma | ← GREENSCHIST FACIES → | | | | | | | |
| | | α, γ-serp + carb<br>± ant | bl. gr. hbl + act + chl + plag + Q<br>± ep/cl | plag + Kfsp + bi + ms<br>+ chl + Q | plag + Kfsp + bi + ms<br>+ chl + Q | bi + chl + ms + plag + Q | act + chl + plag + Q<br>± ep/cl ± bi | ? ? | |
| $F_4/M_3$ | | ← AMPHIBOLITE FACIES → | | | ← UPPER GREENSCHIST- TO LOWER AMPHIBOLITE FACIES → | | | | |
| | | ← development of main foliation → | | | | | | | |
| | | gram + chl ± ant<br>± bl. gr. hbl | bl. gr. hbl + plag + Q ± sph<br>± ep/cl | plag + Kfsp + bi + ms + Q | plag + Kfsp + bi + ms<br>+ Q | bi + ms + plag + Q | bl.gr.hbl + plag<br>± bi ± Q | plag + Kfsp + bi + ms + Q in granites; bl. gr. hbl + act + sph in mafic dikes<br>granite intrusion | |
| $F_3/M_2$ | 310 Ma<br>350 Ma | ← HBL-CPX-ALM-SUBFACIES OF THE GRANULITE FACIES → | | | pre-kinematic ga<br>amphibolite<br>facies? | pre-kinematic ga + bi<br>amphibolite<br>facies? | | | |
| | | ol ± cpx ± opx<br>± br.hbl | cpx + ga + br.hbl + plag + Q<br>± zo ± ru ± sc<br>local migmatization | ga + bi + Kfsp + Q + plag<br>± ms ± ru<br>local migmatization | | | | | |
| $F_2$ | | | minor gabbro intrusion<br>blastomylonitization | | | | gabbro intrusion? | | |
| | 400–<br>450 Ma | | | | granite intrusion | | | | |
| $F_1/M_1$ | 480 Ma | intrusion | (HBL)-CPX-ALM-SUBFACIES OF THE GRANULITE FACIES | | | | | | |
| | | | ga + cpx + plag + zo + Q + ru<br>± br.hbl | ga + bi + Kfsp + Q + plag<br>± ms ± ru | | sedimentation | | | |
| $F_0/M_0$? | Proterozoic? | | ECLOGITE FACIES<br>jad. rich cpx + ga + ky + ru ± zo | | | | | | |
| | | | emplacement of mafic rocks | sedimentation | | | | | |

*) recalculated using the decay-constants recommended by Steiger & Jaeger (1977).

Table I. Inferred geological history.

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## DISCUSSION

Although field relationships are rather hard to assess in the Teijeiro area, mineral relationships, particularly in the mafic granulite facies rocks, reveal a metamorphic and structural history which has been schematized in Table I.

As stated above, van Calsteren (et al., 1979), by obtaining an isochron on migmatic mafic granulites at Cabo Ortegal, was able to date the second phase of granulite facies metamorphism (347 ± 17, recalculated with $\lambda_{Rb} = 1.42 \times 10^{-11} a^{-1}$). This age, together with other age data from West Galicia (van Calsteren et al., 1978; Priem et al., 1970) and geochemical data from the Cabo Ortegal complex (van Calsteren, 1978) led to a hypothesis of a mantle plume as the cause of the Early Palaeozoic events in West Galicia (van Calsteren & Den Tex, 1977). The high-grade metamorphism, the abundance of granitic rocks, and the strong differential vertical movements, apparent from the juxtaposition of rocks of different metamorphic grade, can more easily be explained by such a model than by a model invoking colliding lithospheric plates (van Calsteren, 1977; Krebs, 1976; Zwart, 1976). When the geology and the geological history of the Teijeiro area are described in terms of this model, the following scheme appears: The central ultramafic rocks can be regarded as a second order diapir which intruded continental crust in Cambrian or Early Ordovician times. Eclogite facies conditions reigned in the lower parts of this crust, which consisted of mafic and sedimentary rocks. As a consequence of the heat of the second order diapir, the local geothermal gradient steepened, resulting in conditions of the cpx-alm-subfacies. The scattered occurrences of eclogites and of cpx-plag-symplectites in granofelses can be ascribed to an incomplete reaction and adaption to the new conditions, possibly due to the lack of a fluid phase. In the metasedimentary parts of the crust, an incipient mobilization took place in the driest parts, as can be inferred from the concentration of K-feldspar and quartz in augen and streaks in the ga-bi-gneisses. The precursors of the augengneisses which surround the high-grade metamorphic parts must have been generated by anatexis of more hydrated parts of the metasediments during this stage in view of the 400 Ma whole-rock age of the Mellid gneisses (van Calsteren et al., 1979). That at least the Mellid gneisses contain an old crustal component is apparent from U-Pb zircon data which have revealed an Early Proterozoic upper intercept age (Kuijper et al., 1977).

As the next stage the generation of gabbroic liquids by partial melting of the second order diapir can be regarded (van Calsteren, 1978). It can be hypothesized that both the larger Teijeiro gabbro as well as the small gabbro intrusions in the high-grade parts were generated at roughly the same time, whereby the Teijeiro gabbro, due to its greater volume, was able to intrude to a higher level, while the smaller gabbros did not have enough buoyancy. However, no evidence in favour or against such a hypothesis has yet been found. The second phase of granulite facies metamorphism in the lowest parts of the crust took place more or less contemporaneously. Possibly the slight increase in $P_{H_2O}$ can be related to $H_2O$ escaping from partial melts generated in the second order diapir, since the ultramafic rocks at Cabo Ortegal carry phlogopite-edenite (hence $H_2O$-bearing) veins and lenses which possess the same ages (350 Ma) as the migmatic granulites. Vertical movements due to crustal thinning and updoming by the large mantle plume (i.e. the first order diapir) began already before this phase, as indicated by blastomylonitic textures in the mafic granulites. These movements continued while the heat front of the mantle plume rose upwards, causing a steepening of the regional geothermal gradients. This resulted in more widespread anatexis in higher parts of the crust, giving rise to the Coba de Serpe granites and, somewhat later, the Espenuca granite. The regional amphibolite and greenschist facies metamorphism was also caused by this heat front. Continued vertical movements brought the lower crustal rocks into juxtaposition with the low-grade supracrustal rocks. The above-described geological history is an attempt to clarify the mantle plume model using data from a small area in West-Galicia. As such, the picture is totally consistent with the extensive description of the regional geology of Galicia, given by E. Den Tex (this volume).

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