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BASEMENT ROCKS OF WESTERN GALICIA AS SOURCES FOR THE MINERALS IN THE RIA DE AROSA

BY

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ABSTRACT

The geology of the hercynian orogen in western Galicia is briefly outlined with special reference to the drainage area of the Ría de Arosa. The possible host rocks of translucent heavy minerals found in unconsolidated sediments within and around the ria are tabulated and discussed.

RESUMEN

La geologia del orógeno herciniano en la parte occidental de Galicia, especialmente el área de captación de la Ría de Arosa, está resumida. Se discute cuales son las rocas primarias de los minerales pesados traslúcidos encontrados en los sedimentos no consolidados dentro y alrededor de la ría. Estos son representados en el cuadro 1 para las áreas de captación de los ríos Ulla y Umia y en el cuadro 2 para la región directamente circundante a la Ría de Arosa.

INTRODUCTION

The Ría de Arosa is situated within the hercynian orogen that occupies a large area in the western part of the Iberian Peninsula. It has a slightly curved shape; average strikes vary from W-E in the south over NW-SE in the centre to N-S in Galicia, the northwestern corner of the peninsula (cf. fig. 1).

Western Galicia belongs to a relatively deeply eroded part of the orogen, characterized by abundant regional-metamorphic rocks and granites. Both to the south, in northern Portugal, and to the east, in eastern Galicia and the neighbouring provinces of León and Zamora, higher levels of the orogen are exposed. In these areas regional-metamorphic rocks are not rare either, but often they could be traced along their strikes into areas of lower metamorphism, where it has been possible to establish a stratigraphic succession, partly dated by fossils (see e.g. Matte, 1967). Strong deformation in several successive phases, metamorphism, and the abundant emplacement of granites rendered the recognition of the metamorphosed equivalents of these stratigraphically dated rocks so far impossible in western Galicia[1]).

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[1]) In the area S of Orense Ferragne (1966) on lithological grounds assigns an Infracambrian to Silurian age to a series of schists with intercalated quartzites, detrital volcanic sediments and metarhyolites.

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PRE-HERCYNIAN ROCKS

Three groups of pre-hercynian rocks can be distinguished in western Galicia:

a. Metasediments: mainly pelitic schists and plagioclase-bearing paragneisses (metapelites and metagreywackes respectively) with very subordinate intercalations of quartzite and graphite schist;

b. Basic and ultrabasic rocks with a metamorphic grade varying from greenschist facies to high-pressure granulite facies;

c. Granite-gneisses, varying in composition from quartzdioritic to per-alkaline granitic, and with blastomylonitic or blastophyllonitic textures; (rare) metarhyolites.

As appears from the geological map (fig. 1), metasediments are present everywhere in western Galicia. Paragneisses are found as a major rock-type in a narrow belt between Malpica and Túy, within which and along which a large part of the granite-gneisses also crop out. Because of the frequent occurrence of blastomylonitic granite-gneisses and on account of its

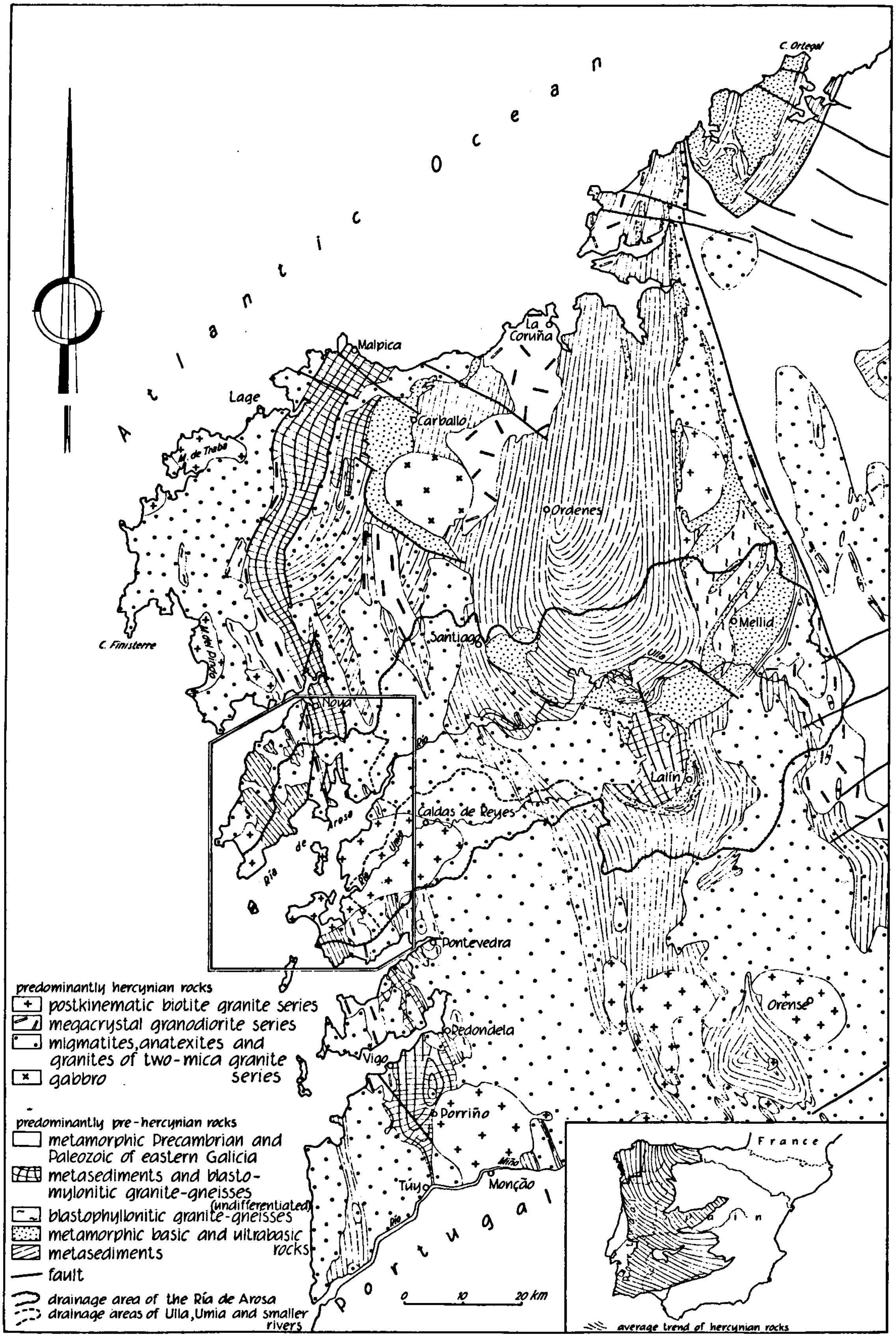

Fig. 1. Simplified geological map of western Galicia. After Parga-Pondal (1963) and mainly unpublished data of the Department of Petrology, University of Leiden. Scale 1 : 1.000.000.

structural features the belt has been named "blastomylonite graben" by den Tex & Floor (1967). Outside the belt granite-gneisses mostly have a blastophyllonitic texture. To the W and NW of Lalín another complex of blastomylonitic granite-gneisses is found.

Metabasic and ultrabasic rocks are mainly concentrated in a discontinuous arc through Carballo, Santiago de Compostela and Mellid up to the area of Cabo Ortegal, where a complex of high-grade metamorphic rocks is found (Vogel, 1967). In the neighbourhood of this arc of basic rocks granite-gneisses are locally abundant as well. Small but numerous lenses of amphibolite are common in the "blastomylonite graben". Elsewhere metabasic rocks are rare. There are textural, mineralogical and compositional indications that some basic rocks have a sedimentary origin (Floor, 1966).

Isotopic age determinations were made of some granite-gneisses collected in the southern part of the "blastomylonite graben". They gave whole-rock ages of about 500 m.y. (Priem et al., 1966). Age determinations of granite-gneisses from other parts of western Galicia are being carried out at present.

HERCYNIAN METAMORPHISM AND INTRUSIVES

During the hercynian orogeny all rocks mentioned above were deformed and metamorphosed, some of them for the first time (granite-gneisses, some basic and ultrabasic rocks and metasediments), others for the second time (metasediments, many basic and ultrabasic rocks; see den Tex, 1966).

Metamorphism was locally of such a grade that the rocks were subjected to partial melting with formation of migmatites, anatexitic granites and, at deeper levels, also of homogenized granites capable of intrusion. The members of this two-mica granite series are leucocratic and characterized by the presence of biotite, muscovite and plagioclase with anorthite contents generally below 15 per cent. The rocks have either linear or planar oriented or unoriented textures and display many shapes of outcrop (from elongate via irregular to about circular) thereby demonstrating their syn- to postkinematic character.

In addition to the two-mica granite series two clearly intrusive granite series are found. The oldest one is intrusive into migmatic rocks but was itself intruded by homogeneous two-mica granite. The main type is a megacrystal-bearing granodiorite; hornblende and biotite-bearing granodiorite and quartzdiorite without alkalifeldspar megacrysts are found locally within the megacrystal-bearing type. Rocks of this series seem to be mainly restricted to the loci of fundamental NNW-SSE striking faults (e.g., the fault zone separating eastern Galicia from western Galicia and the fault zone delimiting the "blastomylonite graben" to the west). They have often been deformed together with the older two-mica granites and country rocks by late-hercynian flattening.

The other intrusive granite series is completely postkinematic and occupies mainly oval-shaped bodies (e.g., the Porriño-Monção, Caldas de Reyes, Pindo, and Traba granites). These intrusions are often composed of more than one type. Clearly intrusive relations between the types could sometimes be observed. The structure is generally porphyritic to coarse-grained inequigranular depending on the relative size of the minerals between the alkalifeldspar phenocrysts, which rarely measure more than 4 cm. Biotite is never absent; some types contain a dark green amphibole in addition, others muscovite.

An intrusive gabbro complex of hercynian age is situated N of Santiago de Compostela. West of Mellid some small gabbro intrusions were found.

Lamprophyres and dolerite dykes are the youngest intrusive rocks in W Galicia. Their number is small.

For a summary of the results of recent geological investigations in western Galicia the reader is referred to the proceedings of the "Primera reunión sobre geología de Galicia y norte de Portugal" (1965, published in 1966).

SUPPLY OF MINERALS TO THE SEDIMENTS

Since the purpose of the present paper is to provide a regional geological basis for the discussion of the sediments of the Ría de Arosa, it is thought that this purpose is served best by the separate description of the drainage areas of the Ulla and Umia Rivers and the area immediately surrounding the Ría de Arosa. The emphasis will be laid on the localization of possible source rocks of minerals found in the unconsolidated sediments.

The drainage areas of the Ulla and Umia Rivers. — The area drained by the Ulla and Umia Rivers is indicated on the geological map, fig. 1. It can be seen that the Ulla River and its tributaries erode about the greatest variety of rocks to be found in western Galicia: members of all pre-hercynian groups and of two hercynian granite series distinguished in the preceding section. Only postkinematic granites do not occur. The eastern and most complex part of the area is being studied by the Department of Petrology, University of Leiden. The compositions of its rocks are therefore well known.

The drainage area of the Umia River is underlain by a much smaller number of rock-types: metasediments (mainly micaschists), some granite-gneisses, migmatites and granites of the two-mica granite series and members of the postkinematic biotite granite series (the Caldas de Reyes intrusion). Petrographically, the area has not yet been mapped in detail.

TABLE 1

Principal rock-types and their translucent heavy minerals in the drainage areas of the Ulla and Umia Rivers

PRE — HERCYNIAN ROCKS	Metasediments	Micaschists	garnet staurolite chloritoid	andalusite sillimanite (near granites) zircon		monazite anatase tourmaline (mainly bluish green)	
		Paragneisses	garnet (mainly turbid) staurolite	andalusite kyanite (mainly E of Santiago de Compostela) sillimanite (near granites)		tourmaline (mainly brown-green) zircon	
	Metabasic rocks	Greenschists	actinolite	pistacite clinozoisite	titanite anatase	zircon	
		Amphibolites	green amphibole colourless amphibole (cummingtonite)	pistacite clinozoisite	zoisite zircon	titanite rutile	
		Garnet amphibolites	light brown amphibole garnet	rutile zircon	zoisite		
		Granulites	clinopyroxene light brown amphibole	kyanite garnet	pistacite clinozoisite	zoisite rutile	zircon
	Ultrabasic rocks	Peridotites and serpentinites	enstatite colourless amphibole	garnet green spinel	rutile		
	Granite-gneisses	Blastophyllonitic and blastomylonitic types	dark green amphibole garnet	pistacite sillimanite	titanite anatase	monazite zircon	
HERCYNIAN ROCKS	Megacrystal granodiorite series		titanite	zircon			
	Two-mica granite series	Migmatites, anatexitic and homogeneous granites	sillimanite tourmaline (mainly brown)	monazite zircon	anatase	in pegmatites/aplites also:	garnet tourmaline (blue)
	Postkinematic biotite granite series		dark green amphibole pistacite	monazite zircon	titanite		
	Gabbro		clinopyroxene hypersthene	enstatite brown amphibole	brownish green amphibole		
	Dolerite dykes		titanaugite	brown amphibole			

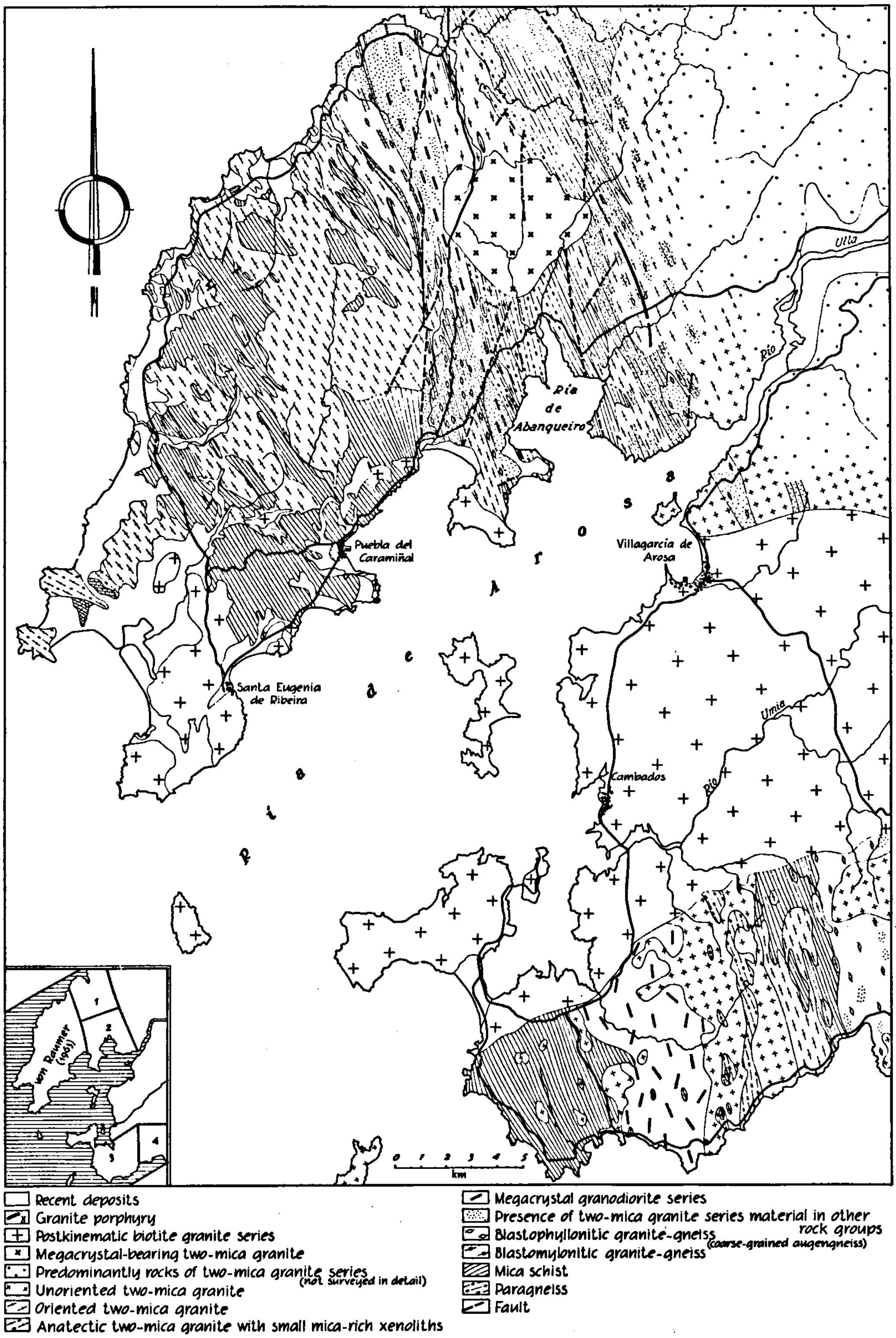

Fig. 2. Geological map of the Ría de Arosa area. After von Raumer (1963), Parga-Pondal (1963), unpublished reports of the Department of Petrology, University of Leiden, by C.E.S. Arps (1), J. B. M. ten Bosch (2) revised by C. E. S. Arps, W. Vogel (3) and N. Rengers (4), and personal observations of the author. Scale 1 : 250.000.

The most important rocks, with the translucent heavy minerals they could supply to the Ulla and Umia river systems, are listed in Table 1.

The country around the Ría de Arosa. — The coast and hillsides drained by small rivers flowing directly into the Ría de Arosa are constituted of about the same rock-types as the drainage area of the Umia River, but their distribution is better known through the investigations of von Raumer (1963) and the Department of Petrology, University of Leiden (fig. 2). Translucent heavy minerals found in thin sections of rocks from this area are listed in Table 2.

Rocks belonging to the "blastomylonite graben" are present only on the northern shore of the Ría de Arosa[2]). They comprise plagioclase-bearing paragneisses, two-mica schists, a few thin bands of quartzite and graphite schist, granite-gneiss and some amphibolite lenses. Hercynian megacrystal granodiorite and several types of two-mica granite intruded into this complex. Calcsilicate rocks are found as rare xenoliths in megacrystal granodiorite.

Outside the "blastomylonite graben" micaschists predominate. Coarse-grained augengneisses (blastophyllonitic granite-gneisses) run parallel to and not far from the boundaries of the "graben". Calcsilicate rocks are found intercalated in micaschists in the extreme SW part of the area. W of the "graben", schists and augengneisses are intruded by the Barbanza two-mica granite[3]).

The structural continuity between the larger inliers and schists surrounding the granite demonstrates that the former should be considered as roof pendants. Andalusite is very common in the schist, garnet often absent, whereas of staurolite only a few grains were found in schist xenoliths in the Barbanza granite. The granite has a weak subvertical NW-SE foliation.

East of the "graben" two-mica granites are abundantly present as well. Their country rocks often have a migmatic aspect contrasting with the generally non-migmatic gneisses and schists to the west. Translucent heavy minerals in the migmatic rocks are incorporated with those of the two-mica granite series on Table 2.

Before the intrusion of some relatively young granites the rocks in the area were in places deformed by an ENE-WSW flattening compression, causing e.g. a strongly phyllonitic structure in the megacrystal granodiorites and some two-mica granites, and a new cataclastic texture in the blastomylonitic granite-gneisses.

[2]) South of the ria they are not very characteristically developed and crop out in the extreme SW of the drainage area of the Umia River.

[3]) After Sierra de Barbanza, the ridge on the peninsula north of the Ría de Arosa.

The megacrystal-bearing two-mica granite situated north of the Ría de Abanqueiro is considered as the youngest member of the two-mica granite series. Its age relation with the Caldas de Reyes intrusion cropping out both north, within and south of the Ría de Arosa could not be established by observations in the field. Both complexes are clearly postkinematic.

The Caldas de Reyes intrusion, though depicted as a homogeneous mass on the geological maps, is in fact composed of several types of granite, intrusive into each other. The complex has not yet been mapped and investigated petrologically. Qualitatively, the variations can be studied excellently in the many quarries present everywhere in the complex, but mapping of types will be difficult owing to lack of natural outcrops. The variations are mainly structural.

Coarse-grained inequigranular biotite granite is the most common type. The number of potassium feldspar crystals is too great and the grain of the ground mass too coarse to call this type coarsely porphyritic. Irregularly shaped concentrations of alkalifeldspars with very subordinate quantities of interstitial quartz, plagioclase and biotite are seen in some outcrops. Locally, dark green amphibole is found in addition to biotite. It is not known whether this is a variety of coarse-grained biotite granite or a separate type.

Other members of the intrusion are medium to fine-grained and can be distinguished by their content and habit of biotite and the presence or absence of some alkalifeldspar megacrysts. Their composition is granodioritic.

Medium-grained equigranular two-mica granite has been found as a small mass N of Cambados and as xenoliths in many types of biotite granite. The rock must therefore be relatively early in the intrusive sequence of the complex or even be older than the whole complex (xenoliths of a member of the two-mica granite series).

Late in the magmatic history of the complex, an autometasomatic phase caused the alteration of the granite with the formation of strongly pleochroic green epidote, probably at the cost of biotite, and partly concentrated in veins. This alteration can be seen to start along joints and veins and to work gradually into the granite. Where this phenomenon has acted most completely (mainly on the northern shore of the Ría de Arosa near Santa Eugenia de Ribeira and Puebla del Carmiñal), the granite has a conspicuous brick-red colour.

Pre-existing rocks, belonging to groups that crop out north and south of the intrusion, are found as xenoliths, roofpendants or septa, e.g., in a series of quarries along the western extremity of the harbour of Villagarcia de Arosa.

TABLE 2

Principal rock-types and their translucent heavy minerals in the area surrounding the Ría de Arosa

PRE — HERCYNIAN ROCKS	Metasediments	Paragneisses	garnet (mainly turbid) tourmaline (mainly brown-green)	sillimanite (near granites) zircon		
		Micaschists	andalusite garnet (only locally)	sillimanite (near granites) tourmaline (bluish green, brown-green in tourmaline-enriched selvages of dykes and veins)	zircon	
		Calcsilicate rocks	clinopyroxene green hornblende	garnet	pistacite clinozoisite	rutile titanite
		Quartzites	zircon	monazite		
		Graphite schists	zircon			
	Amphibolites		green hornblende cummingtonite	pistacite clinozoisite	titanite zircon	
	Granite-gneisses	Blastophyllonitic augen-gneisses	garnet (only W of „blastomylonite graben"	tourmaline (brown) sillimanite	zircon	
		Blastomylonitic granite-gneisses	garnet (rare)	pistacite	zircon	
HERCYNIAN ROCKS	Megacrystal granodiorite series		zircon	titanite		
	Two-mica granite series	migmatites anatexitic and homogeneous granites	sillimanite andalusite (rare)	garnet (rare) tourmaline (brown-green)	monazite zircon anatase	in pegmatites/aplites: garnet tourmaline (blue)
	Postkinematic biotite granite series		dark green amphibole pistacite	monazite zircon	green pleochroic epidote in autometasomatically altered granite	
	Dolerite dykes		titanaugite	brown amphibole		

CONCLUSIONS

1. The disposition of rock-types in the drainage areas of the rivers discharging into the Ría de Arosa is such, that within and along this ria the variety of translucent heavy minerals in the unconsolidated sediments can be expected to be the greatest of all western Galicia.

2. This variety is due mainly to the erosion of rocks by the Ulla River and its tributaries.

3. Notable is the small amount of garnet, staurolite, clinopyroxene, amphibole and the absence of kyanite, zoisite, chloritoid, spinel, orthopyroxene in rocks of the area immediately surrounding the Ría de Arosa. This is not due to incomplete regional knowledge, because the greater part of the area has been petrographically investigated.

4. Corundum and brookite were never observed in thin sections. Corundum, however, is known to occur in andalusite-quartz nodules in micaschists near the Portuguese frontier SW of Túy (Parga-Pondal & Martin Cardozo, 1952), of which the schists in the W part of the Ría de Arosa area may very well be the continuation. Brookite is probably a mineral formed during alteration and weathering of titaniferous minerals and therefore not observed by hard-rock petrographers.

REFERENCES

Contribuciones a la primera reunión sobre geología de Galicia y norte de Portugal (1965), 1966. Leidse Geol. Med., p. 205—320.

Ferragne, A., 1966. Sur l'existence d'une série volcano-détritique silurienne au Nord de Celanova (Province d'Orense, Espagne). C. R. Acad. Sc. Paris, 262, p. 832—834.

Floor, P., 1966. Petrology of an aegirine-riebeckite gneiss-bearing part of the Hesperian massif: the Galiñeiro and surrounding areas, Vigo, Spain. Leidse Geol. Med., 36, p. 1—203.

Matte, Ph., 1967. La schistosité primaire dans l'arc hercynien de Galice; variation de son pendage parallèlement et perpendiculairement aux structures et rôle des phases de déformation ultérieures. *In*: Etages tectoniques, Ed. la Baconnière, Neuchâtel, p. 243—251.

Parga-Pondal, I., 1963. Mapa petrográfico estructural de Galicia. Inst. Geol. Min. Esp.

Parga-Pondal, I. & Martin Cardozo, M., 1952. Estudio de la diáspora con corindón y andalucita de Goyán (prov. de Pontevedra). Notas y comun., Inst. Geol. Min. Esp., 26, p. 163—168.

Priem, H. N. A., Boelrijk, N. A. I. M., Verschure, R.H., Hebeda, E. H. & Floor, P., 1966. Isotopic evidence for Upper-Cambrian or Lower-Ordovician granite emplacement in the Vigo area, north-western Spain. Geol. en Mijnb., 45, p. 36—40.

von Raumer, J., 1963. Zur Tektonik und Genese des nordwest-spanischen Kernkristallins bei Noya (La Coruña). Geotekt. Forschungen, 17, p. 1—63.

den Tex, E., 1966. Aperçu pétrologique et structural de la Galice cristalline. Leidse Geol. Med., 36, p. 211—222.

den Tex, E. & Floor, P., 1967. A blastomylonitic and polymetamorphic „graben" in western Galicia (NW Spain). *In*: Etages tectoniques, Ed. la Baconnière, Neuchâtel, p. 169—178.

Vogel, D. E., 1967. Petrology of an eclogite- and pyrigarnite-bearing polymetamorphic rock complex at Cabo Ortegal, NW Spain. Leidse Geol. Med., 40, p. 121—213.

Warnaars, F. W., 1967. Petrography of a peridotite-, amphibolite- and gabbro-bearing polyorogenic terrain NW of Santiago de Compostela (Spain). Thesis, University of Leiden.