LEIDSE GEOLOGISCHE MEDEDELINGEN, deel 40, p. 75—78 published separately 1-8-1967

EXCURSIONS IN THE CATAZONAL ROCK COMPLEXES OF THE POLYOROGENIC TERRAIN OF CABO ORTEGAL (NW. Spain).

BY

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This excursion program anticipates the publication of a PhD. thesis (Vogel, in preparation) in this periodical and is intended as a guide to those points at Cabo Ortegal, that are readily accessible, well exposed and of general petrological interest. The described localities are indicated on a small map (fig. 1) and can also be found on the 1 : 25,000 topographical maps edited by the Cartografia Militar de España: sheet 1 (quadrants I, Cabo Ortegal; II, Ortigueira and III, Pontigás) and sheet 7 (quadrants I, Feria and IV, Cedeira) or on the 1 : 50,000 topographical maps edited by the Instituto Geográfico y Catastral, Madrid: sheets 1 (Ortigueira) and 7 (Cedeira). The author is grateful to Prof. Dr. E. den Tex for reading and correcting the text.

EXCURSION I, duration 2 or 5 h.; to be made preferably on Sunday. Start before Bar Bahia, Cariño.

1. Follow the road to the harbour: just before arriving at the breakwater (built from eclogite) a quarry in the Cariñogneiss is found at the left-hand side of the road. In the quarry, an anticlinal fold, disrupted along small subvertical fault-planes, is exposed. The banding that can be seen in the paragneisses is compositional; garnet-two-mica gneisses of psammitic composition, which have reacted competently to folding, alternate with microfolded garnet-two-mica gneisses of more pelitic composition. The folding has caused a tectonic banding in the pelitic gneisses; relics of kyanite and staurolite, predating the folding, may be found in this type of gneiss.

2. Return to Bar Bahia and follow the road to the eclogite quarry on Monte Castrillón. As the road is narrow, delay is prevented by making the visit on a holiday so that no encounters with rock carriers are risked. Leave your car on the side-road near the last houses of Cariño and descend along a narrow pathway to the beach, where folds in the Cariñogneiss with steeply eastward dipping Western limbs and gently westward dipping Eastern limbs are well exposed. This visit should be made at low tide and can eventually be left until the return journey.

3. Continue along the road to the quarry; note the change in texture between the even-grained, even-textured Cariño gneiss and the finely banded glandular texture of the banded gneiss in the exposed sides of the roadcut. Leave your car in the quarry. Here a continuous exposure of some 200 m. length has been made in eclogite. The eclogite itself is of an α-zoisite carrying variety. It can be found in every conceivable stage of amphibolization. In the tailings, tectonized types with cm.-size garnets (representing a hornblende granulite facies retrograde metamorphic stage) and eclogites cut by zoisite bearing veins may be found.

4. Proceed to the southern end of the quarry where a small track leads to the top of the M. Castrillón. In weathered outcrops the eclogite can be seen to have a schistose texture which dips steeply towards the West. About a 100 m. further westward one strikes the first exposures of the Capelada complex, where retrograded pyrigarnites can be found interbanded with garnet leptynites. The Hercynian fold pattern is illustrated by an anticlinal culmination with gently North- (at the northern end) and South- (at the southern end) plunging fold axes. It is located another 50 m. westwards.

5. Those who wish to visit the garnet pyroxenite veins that occur at the Limo, must be prepared to prod an extra 3 hours through densely gorse-covered terrain in which no tracks are present. To prevent painful contact with the gorse scrub as much as possible, the advised course should be followed on the outgoing trip as well as on the return trip.
Proceed from locality 4 in a westerly direction past the crucifix (crucero), climb to the top of the ridge that runs in a south-westerly direction and follow it to the summit of the Limo (alt. 562 m.). From here, another ridge with good exposures runs in a northern direction seawards. At an altitude of about 460 m. on this ridge (650$\pm$ m. from the top), the garnet pyroxenite veins, microfolded on roughly North plunging axes — sometimes carrying individual garnets or garnet-aggregates with a length of up to 5 cm.— are found lying in strongly serpentinized pargasite-peridotite.

EXCURSION II, duration 1-2 h. Starting point Cariño. Not to be made at high tide.

1. Proceed by car to La Piedra and turn left, direction Figueiroa. Follow this road for about 1¼ km. Right in the last bend before the village of Figueiroa, a wood path turns to the right (West). Leave the car and follow this path until just beyond the first hair-pin bend. In a small (2 × 2 m.) excavation in the left-hand (eastern)

side of the path, remnants can be found of a meta gabbro lens in the banded gneiss. Samples of both completely (carinthine eclogite) and partly eclogitized gabbro can be found here.

2. Return to the car and drive on in an easterly direction. Park the car at the end of the road and descend to the beach. Walking in NW direction a well exposed section is passed which gives a good idea of the relations between the banded gneiss and its inclusions of (retrograde) eclogite. A detailed description of this section is given in the abovementioned thesis (Vogel, in preparation).

EXCURSION III, duration 3 h. Starting point Puente de Mera.

1. Proceed to Quinta; leave the car at the intersection with the road to Leija. Turn left into the westward leading path. Keep to the left at the first bifurcation and thereafter take the first path to the right, which immediately starts climbing. In the path, which leads through the hamlet Peña do Vilar, the interbanding of banded gneiss and (retrograde) eclogite is well exposed.

2. At an altitude of about 250 m. the path levels out and a small track leads eastward to the eclogite exposures of the Monte Castro. The eclogite, a fine-grained α-zoisite eclogite, contains a band of coarse-grained α-zoisite eclogite which passes into a medium- to coarse-grained β-zoisite- amphibole eclogite; an alteration that is accompanied by a change in texture.
From this point the view is magnificent. To the East lies the Ria de Santa Marta de Ortigueira; to the North the Miranda with its three eclogite ridges and to the South the eclogites of the Alto da Foxo. Immediately West of the exposure the remnants of a celtic fortification may be seen.

3. Return to the path and continue for about 50 m. westward. Exposed in the bottom of the path — between the eclogite of the M. Castro and the continuation of the eclogite ridge of the A. da Foxo — banded gneisses are again exposed. Those who wish to see more eclogite can continue westward until La Cruz and take the path leading South. From this path either of the two well exposed ridges that run North from the Concepenido and the A. da Foxo can be climbed. As a rule good eclogite exposures can be found on the following hilltops: Sierra de Moles, Concepenido, A. da Foxo, Miranda, Castrillon, Faroleiro and Aguillón.

EXCURSION IV, duration 3-4 h. Starting point Cedeira, petrol station in front of Bar Playa. To be made at low tide.

Take the road leading to Chimparra passing first through the Chimparragneiss, and beyond the bridge over the Rio Condomiñas through Candelaria amphibolite. Leave the car in Chimparra and proceed through the Chimparragneiss along the slowly climbing path to San Andres, until the boundary between gneiss and serpentinized peridotite is reached. Then climb northward towards the small depression that lies between the gneiss and the serpentinized peridotite. From here, a small track leads eastward and downward to the eastern edge of the Playa de Cartés. On the way down, the site where pinkish-brown coloured Uzal ultrabasite overlies the grey coloured rocks of the Capelada complex is plainly visible towards the East. It is advised to visit first the westernmost edge of the beach as this is the first part to be submerged at high tide. Walking from the extreme West of the beach eastward, the following exposures can be seen.

1. Mylonitelike Chimparragneiss of a banded nature, with an s-plane dipping eastward at variable angles. In the gneiss, several pyrigarnite (pseudoeclogite) lenses with amphibolized rims occur arranged parallel to the s-plane.

2. East-dipping tectonic contact of the Chimparragneiss with the Uzal ultrabasite.

3. The ultrabasite is rather ill exposed, but in the large boulders on the beach, pyroxenite veins in serpentinized peridotite can be found as well as small cavities filled with a radial outer rim of anthophyllite and a core of randomly oriented α-chrysotile flakes.

4. A coarse-grained intrusive stock of slightly tectonized leucocratic granodiorite.

5. The tectonic contact between the ultrabasite and the garnet-hornblende rocks of the Capelada complex; with interfolding of garnet-hornblende rock and ultrabasite. The ultrabasite has been displaced along a late, subvertical fault-plane.

6. The exposed rocks of the Capelada complex, mainly basic types (pyrigarnite, retrograde pyrigarnite, garnet hornblende rock etc.) have been intruded by biotite rich granodiorite. Almost every conceivable rock-type, found in the Capelada complex is represented among the numerous well-rounded boulders and cobbles at this end of the beach.

EXCURSION V, duration 3-4 h. Starting point as in IV.

Take the road to Ortigueira, follow it until about 300 m. beyond kilometer-post 4. Here an unpaved road leads to the left (North). This poorly paved road is manageable by cars with not too low a wheel base. Its use after a long period of rains must be advised against. After climbing to an altitude of about 400 m. the road levels off and turns to the East. After a short distance a left hand side road leads again to the North. Continue along this side road which is partitioned by several self operating wooden gates. After about 2 km. the road turns to the North-East while it leads for 2-3 km. over the SE flank of the mountain-ridge around San Andres. Where this ridge turns from its EW to a NS direction, the road leads for a short distance over level terrain. Park the car here at the intersection with the foot-path to San Andres and Teixidelo.

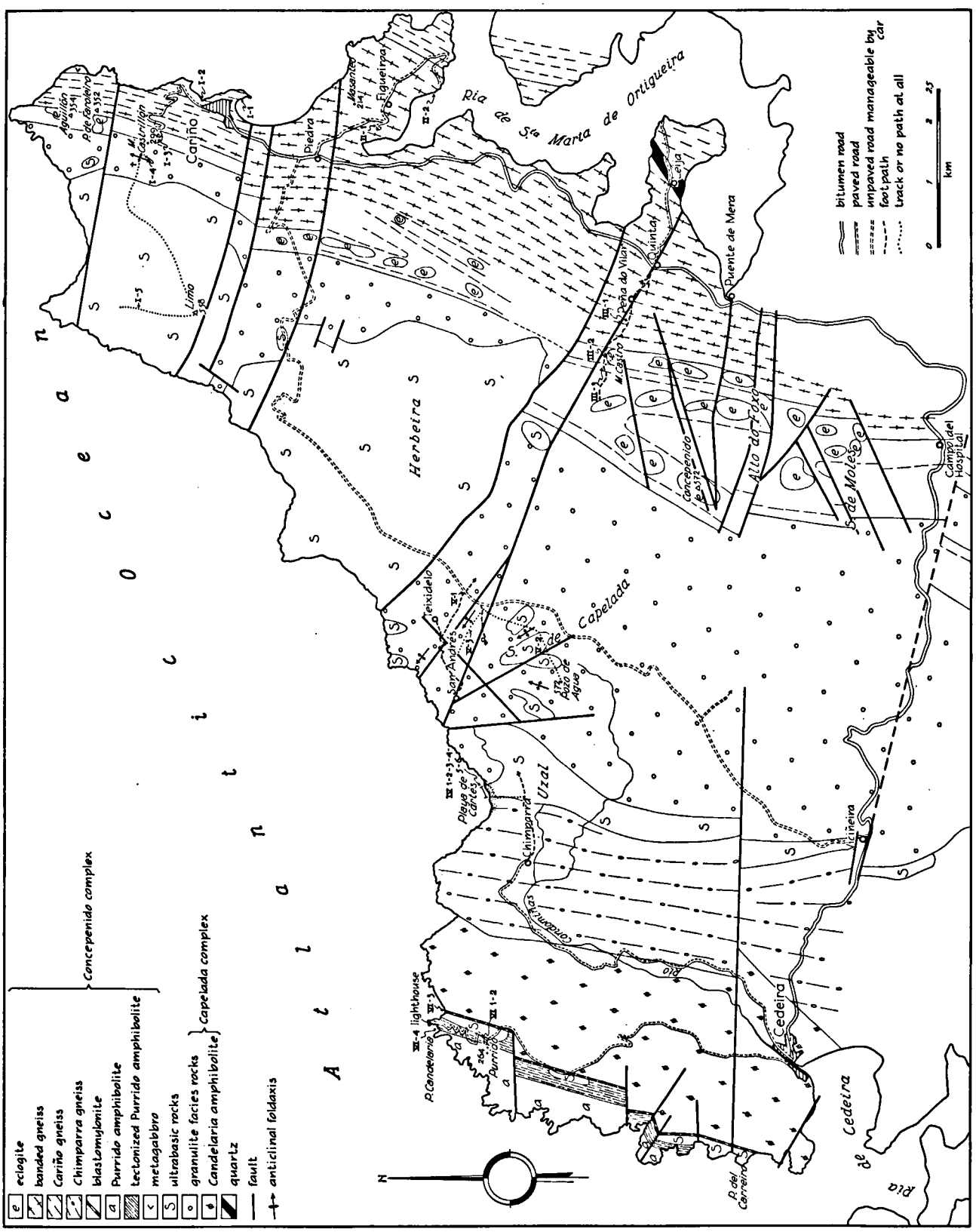

Fig. 1 Geological map of Cabo Ortegal showing routes of excursions. Numbers refer to the text.

1. From about this locality, a foot-path leads in a WSW direction to the top of the ridge around San Andres.

2. Walk from this point in a WSW direction over the ridge towards the Pozo de Agua (alt. 572 m.). Keep on the northern side of the ridge. Ultrabasites and Capelada complex rocks (pyrigarnites and amphibolized pyrigarnites) are exposed in turns. The ultrabasite occurrences are considered to be erosion-relics, situated in the synclinal depressions of the open fold pattern of the rocks of the Capelada complex. The fold-axes of these folds plunge NW on the eastern part and about N. on the western part of the ridge.

3. Return to the footpath mentioned in 1 and descend in a NW direction over the eastern part of the ridge which is in itself an anticlinical culmination with a gently NW dipping s-plane (//plunge of the fold axis) on top and dipslopes on both sides. In the flanks of the fold, small scale isoclinal folds with NW plunging axes are abundantly present. They are thought to have been formed during the mesozonal (Hercynian) metamorphism.
On the other side of the foot-path from San Andres to Teixidelo, the ridge continues some 250 m. more eastward. It has probably been displaced along a SW-NE trending subvertical fault-plane.
From the ridge westward, San Andres can be seen, lying in a depression sheltered on three sides by mountains. More to the West, Uzal ultrabasite, Chimparragneiss and Candelaria amphibolite can be seen successively. To the East lies the ultrabasic massif of the Herbeira, separated from the Capelada complex by an outstanding quartz-vein following a fault. To the SE one can see the eclogites of the Concepenido and the Miranda; a small part of the Ria de Santa Marta de Ortigueira is also visible.

EXCURSION VI, duration 2 h. Starting point as in IV. Preferably to be made at low tide.
Cross the bridge over the Rio Condomiñas and turn immediately right. Follow the road that leads through the Candelaria amphibolites to the light-house at Punta Candelaria. Park the car just beyond kilometer post 6 where a small road leads left (West) to a quarry in the M. Purrido.

1. At some distance before the quarry, a small exposure of ultrabasite with large (∅ up to 2 cm.) bronzites is encountered at the left-hand side of this road. The ultrabasite occurs in this part of Cabo Ortegal as large (and small) lenses in a zone of tectonic movement, which will also be visited at localities 3, and 4.

2. In the quarry, the Purrido amphibolite is mined for building stone. It is characterized by its regularity in appearance and by its extremely well developed schistosity. Irregular, coarse-grained bands, occurring locally and running parallel to the s-plane are considered to be incompletely metamorphosed gabbroic relics.

Descend by car — through the zone of tectonic movement, with Purrido amphibolites on the western side and Candelaria amphibolites on the eastern side — to the light-house. From here a small track leads down to sea level. At the end of the track one is standing in one of the largest ultrabasite lenses of the zone of tectonic movement (length about 1 km., width up to 200 m.). On the eastern side are the blastomylonites (3) on the western side the tectonized Purrido amphibolites (4).

3. The blastomylonite is exposed over its complete width. It is a light-pink coloured rock of banded appearance. Microscopically, bent kyanites, as contrasted with non-bent newly crystallized biotite, testify for the polymetamorphic nature of the blastomylonite. Mylonitization has led to a certain amount of tectonic hybridization, as leucocratic and melanocratic bands and lenses have been drawn out into narrow streaks trailing still undemolished relics. This demolition process can be studied in all its stages of development, in the exposed rocks as well as in the loose boulders. Two of the bigger lenses have been boudinaged and thereafter tilted; their squarish fragments are now lying in an en-echelon arrangement, sub-parallel to the s-plane (that dips E in this part of Cabo Ortegal). One of these lenses with a staggered arrangement consists of metaperidotite, the other of metabasite material. The fragments of the ultrabasic lens all consist of two identically oriented parts: a tough, non-fissile pargasite peridotite (with occasional remnants of garnet) and a crumbling, fissile part, consisting of partially serpentinized pargasite peridotite. Small ultrabasic "fish" surrounded by radial rims of prismatic gedrite may also be found.
At the contract with the Candelaria amphibolites, small fragments have been torn loose from the amphibolite by the mylonitization. A small lens of talc schist is also found at this point.

4. From locality 3 to the West one finds intensively folded Purrido amphibolites, which gradually change into the non-folded schistose type of Purrido amphibolite. In a cove South of the rocky islets just off the coast, the tectonized nature of the Purrido amphibolites can be observed. It is remarkable that amphibolites are competent and incompetent rocks alike. The mobility of plagioclase during the (Hercynian) deformation is illustrated by its segregation in zones of minimum compression (tension-cracks, shear planes).