

Tertiary basins of Spain the stratigraphic record of crustal kinematics

Edited by

PETER F. FRIEND AND CRISTINO J. DABRIO

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W7 North-western Cainozoic record: present knowledge and the correlation problem

A. MARTÍN-SERRANO, R. MEDIAVILLA AND J.I. SANTISTEBAN

Abstract

Tertiary deposits of the north-western Iberian Peninsula are heterogeneous because they occur in several morpho-structural positions as isolated and dispersed basins and outcrops. The quality of the palaeontological record is usually very poor and there are scarce data. Correlation depends on a wide range of criteria which are not always equivalent: palaeontology, mineralogy and petrology, geomorphology, tectonics and comparison with better-known and better-dated facies in regions nearby. The results lack homogeneity and there are notable discrepancies.

Introduction

Tertiary sediments of Galicia, Bierzo and the Cantabrian Range (north-western Spain) occur in small basins and isolated outcrops.

Galicia Basins

Many geographical features and the Tertiary basins of Galicia are related to fault-systems trending N-S, NNE-SSW, NE-SW, E-W and WNW-NW-ESE-SE (Fig. 1).

Lugo Basins

The most important outcrops of Tertiary sediments in Galicia are located in Lugo, between the central peneplain and the eastern mountains. The main basins (Terra Cha, Sarria and Monforte) are asymmetrical: Tertiary sediments rest unconformably upon Palaeozoic rocks in the west and are separated from crystalline basement (igneous rocks) by N20-30 and N50-60 faults (Fig. 2).

The sedimentary fills of the Sarria and Monforte basins, up to 200 m thick, have been divided in various stratigraphical schemes (Briot & Solé, 1954; Brell & Doval, 1974, 1979; Virgili & Brell, 1975; Martín-Serrano, 1979, 1980, 1982; del Olmo, 1986; Vergnolle, 1984, 1985, 1987, 1990) with several lithostratigraphic units which were grouped into the Monteforte Formation (Vergnolle, 1988). The

sedimentary record of the larger basins includes two superposed megasequences of opposed trend (Figs. 3, 4), but it is difficult to differentiate these trends in the smaller, moderately subsiding basins. The lower, fining-upwards megasequence comprises:

- Green arkoses with minor clay matrix (smectite) arranged in channel-form bodies separated by mud layers. These are interpreted as the deposits of rivers that flowed from the granite area of Villalba-Chantada.
- Red-green alluvial-fan conglomerates. These are deposits of small, but thick, alluvial cones rooted in the metamorphic and granitic source areas of the eastern edges of the basins.
- Banded, red-green indurated clay series in the areas where the arkoses and conglomerates coalesce. This facies is more extensive upwards and there is also a progressive the generation of dolomitic crusts associated with palygorskite and sepiolite (Sarria Basin).

The upper, coarsening-upwards megasequence contains green arkosic gravel as the last deposits of the basins infill.

SE Galicia

Three distinct basins occur in the small tilted (towards the Sand SE) mountain blocks of Orens: Maceda, Ginzo de Limia and Verin.

Maceda is a complex, 160 m deep, half-graben bounded to the NNE by a large fault scarp. The lithofacies are different from those of the Lugo basins: the largest part of the basin fill is a fining-upwards fluvial unit of fine-grained sediments (Del Corno and De la Vega Members of Brell, 1975; De los Milagros Member of del Olmo, 1986). They are white, grey and ochre ferruginous sand and clay (55-65% kaolinite) with organic matter, deposited in fluvial environments. The marginal sediments are red muddy sands and gravel, comparable with one of the lithofacies of the Monforte Formation; they are interpreted as alluvial-fan deposits related to the tectonic activity of the border.

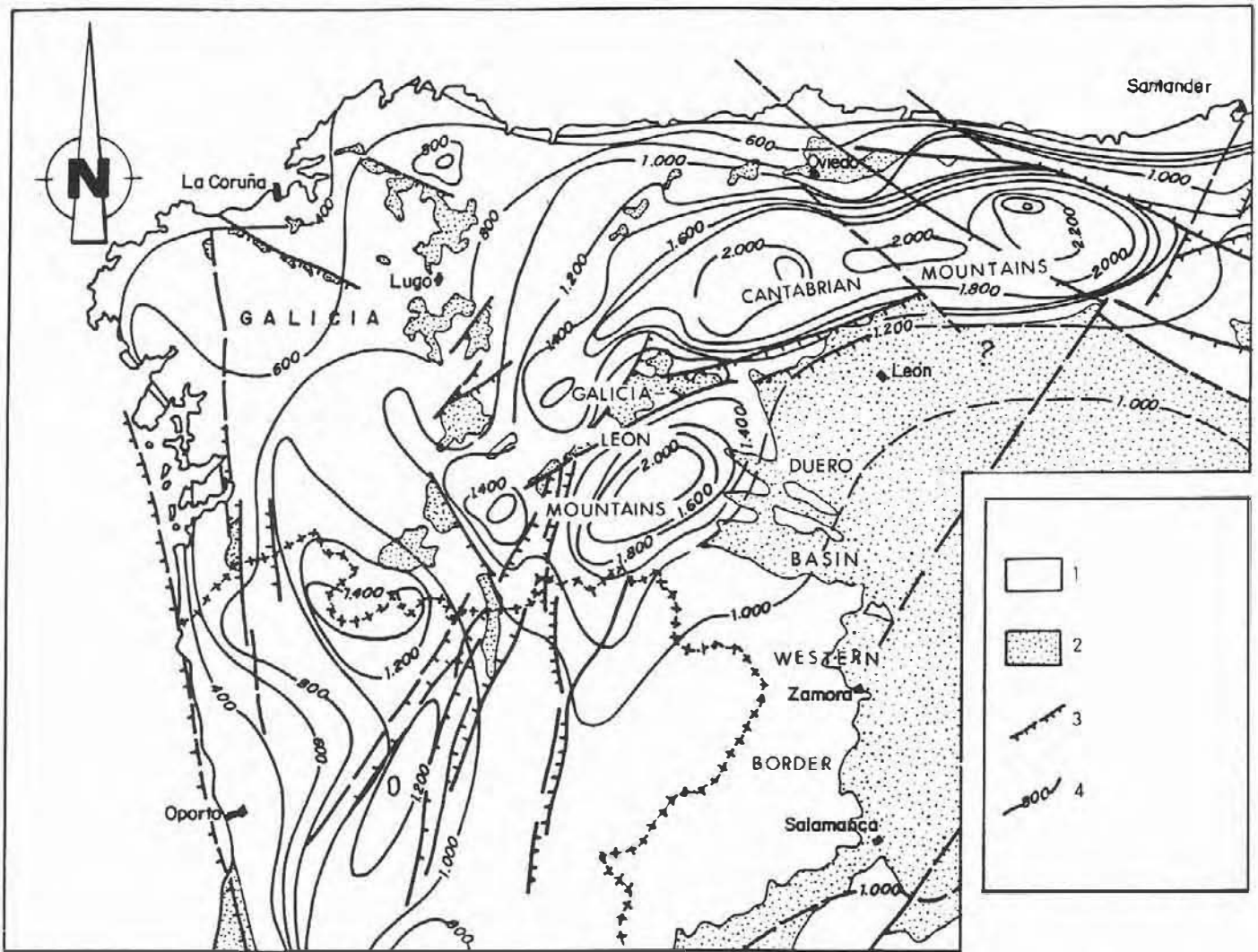


Fig. 1. Morphostructural situation of the north-western Tertiary. 1: Palaeozoic basement and Mesozoic; 2: Cainozoic; 3: Morphotectonic lines; 4: Isohypes of relief contours.

The Ginzo de Limia Basin is a sub-Recent tectonic trough bounded by N70, N-S and N120 faults and filled with alluvial sediments. The fill consists of 250 m of Tertiary sediments, including a lignite and clay layer, located between 80–130 m in depth, and interbedded between two thick sandy series (IGME, 1979–1984).

The narrow Verín Basin, in the morphostructural region of Tras-Os-Montes, reaches a maximum depth of 100 m and is filled with red and grey clay, sand and gravel.

Littoral Basins

These are small, isolated outcrops. Some of them are related to a structural corridor (the so-called Depresión Meridiana, Nonn, 1966): Porriño, Deva and Salvatierra. Other outcrops (Fazaouro Formation) are located on the Cantabrian side (Moucide, Burela and Lorenzana), and they are interpreted as a piedmont (Vergnolle, 1988) made up of fine siliciclastic sediments

related to a regressive episode. These are *siderolithic* facies, with mature constituents from a mineralogical and petrological point of view: kaolinite and unalterable minerals. They are comparable with Maceda, Ginzo de Limia, Puentes de García Rodríguez and Meirama basin fills. The Meirama Basin contains the best developed Cainozoic record of these facies.

The basins of San Saturnino–Pedroso–Mocche–Puentes–Roupar–Moñonovo and Lendo–Meirama–Visantiña–Juanceda–Lauza–Orros–Boimil arc related to dextral faults (Fig. 5) that strongly influenced the sedimentation (Maldonado, 1977; García Aguilar, 1987; Mouge, 1987; Bacelar *et al.*, 1988, 1991; Santanach *et al.*, 1988). They were small, complex, compartmentalised, asymmetrical and strongly subsiding basins (Fig. 6) filled with green, grey and blue kaolinitic muds and sands. In some basins (Pedroso, Puentes de García Rodríguez, Roupar, Juanceda and Meirama) there is lignite as well. They were filled by small alluvial and fluvial systems associated with lacustrine and paludal environments (lig-

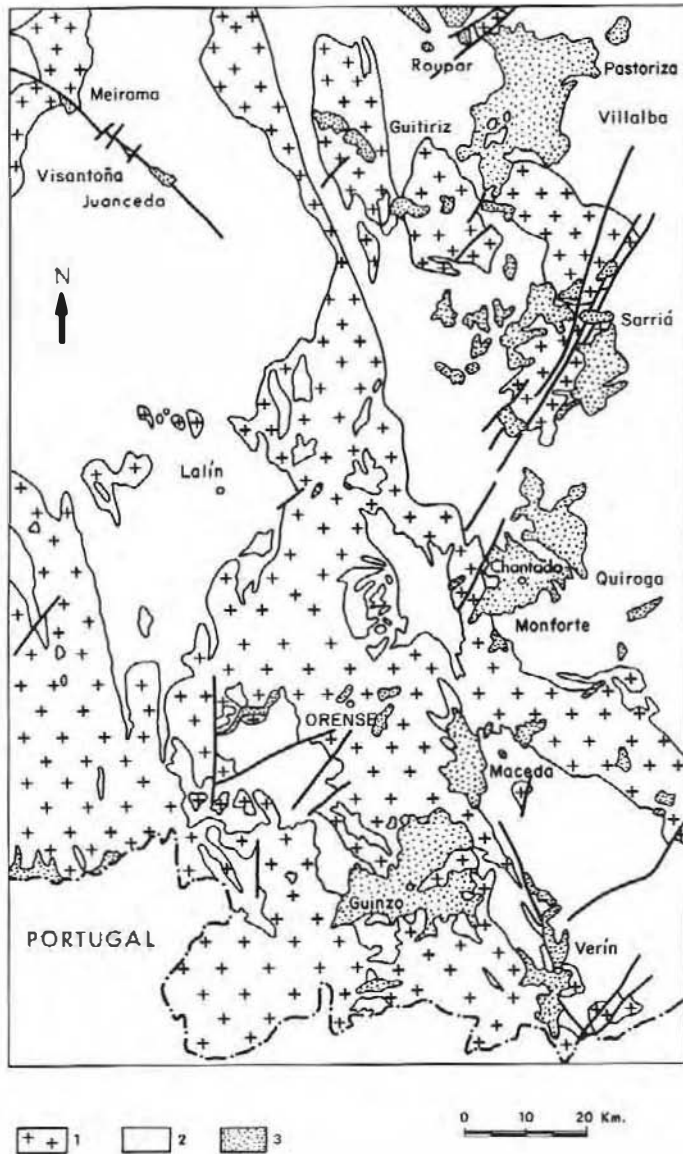


Fig. 2. Tertiary basins in eastern Galicia. 1. Igneous rocks; 2. Palaeozoic and pre-Palaeozoic basement; 3. Cainozoic.

nitic and carbonaceous clays) and were controlled by their structural evolution. Successive extensional or compressional phases in the basin of Puentes were recorded as expansions and retractions of the lignite beds. Equilibrium between subsidence and sedimentation favoured the development of thick coal deposits in the Miramar Basin (Santanach *et al.*, 1988).

Sil corridor

This is the depressed axial area of a NE-SW-trending mountain system. The complex Bierzo Basin (Fig. 7), is the most important Tertiary development. It is a depression with two large basins (Ponferrada-Villafranca and Remihire) surrounded by secondary subbasins to the north (Parradaseca, Finolledo, Fabero

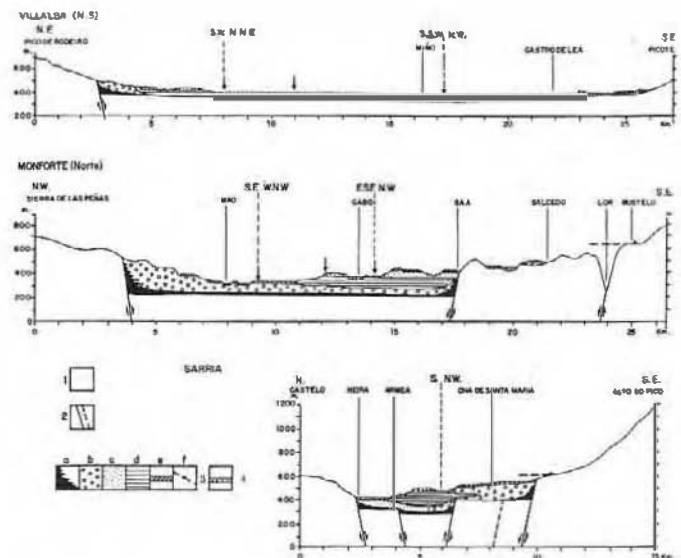


Fig. 3. Lithostratigraphy of the main basins of Lugo Province (from Vergnolle, 1988). 1. Basement; 2. faults; 3. Cainozoic deposits; a: breccias; b: conglomerates; c: arkoses; d: clays; e: dolomitic crust; f: blocks of infill; 4: Quaternary alluvial sheet.

and Noceda) and south (Las Médulas and Carucedo). The other southern depressions (El Barco de Valdeorras, La Rua, Quiroga and Quintela) are small, narrow, fault-bounded deep basins.

The up to 700 m thick sedimentary fill of the Bierzo Basin can be divided into several units (Fig. 8) (Vidal Boix, 1941, 1954; Birot & Solc, 1954; Pannekoek & Sluiter, 1964; Delamire-Bray, 1977; Herral, 1979, 1981, 1984) which serve as a model for the remaining Sil basins:

- Toral Formation: fluvialite gravel and sands and paludal limestone and dolostones (crusts). These are green to pink polymictic smectitic-rich sediments with feldspar, micas and polymineral grains. Source areas are far away to the west with a few local sources (Fig. 9).
- Santalla Formation: beige-ochre or grey-red siliclastic conglomerates and muddy sands deposited in continuously flowing, high-competence fluvio-torrential alluvial fans.
- Las Médulas Formation: matrix-rich siliclastic gravel with boulders, deposited in high-competence, intermittently flowing, alluvial fans.
- These deposits are topped by a weathered *raña*-like sheet of gravel.

All Sil basins underwent a similar evolution as witnessed by the similarity of their sedimentary records. The Quiroga Formation forms the lower infill of the Sil basin, and is laterally equivalent to the Toral Formation; the overlying Monforte Formation has fluvial facies comparable with the Santalla Formation (Figs. 10 and 12).

Morphotectonic features are evident in the Bierzo Basin (NE-SW and E-W borders) and all along the Sil Valley (with narrow and

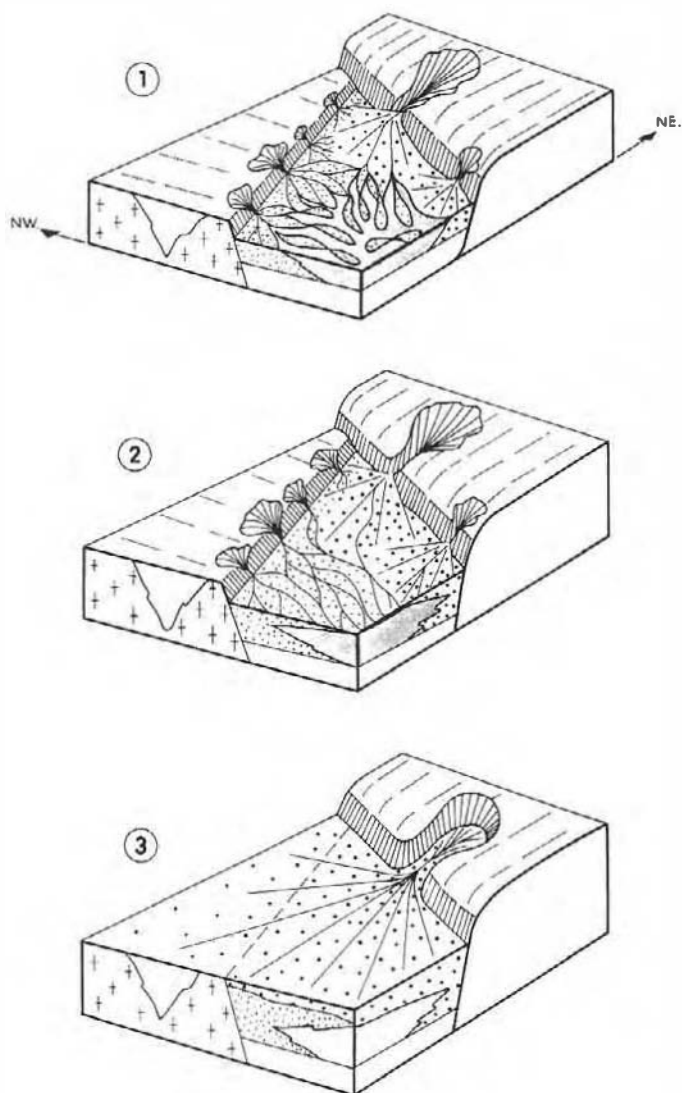


Fig. 4. Paleogeographical reconstruction of the basins filled by the Monforte Formation (simplified from Vergnolle, 1988).

deep N50-60 and N140 basins) (Birost & Sole, 1954; de Groot, 1974; del Olmo, 1986; Vergnolle, 1988). The infill of all these small basins shows a coarsening-upwards sequence. Strong deformation can also be seen affecting the Toral or Quiroga Formations. This deformation has not affected younger sediments such as the Santalla or Las Médulas Formations. The former are syntectonic deposits synchronous with the opening of the Bierzo Basin and Lugo basins.

Asturias outcrops

The Cantabrian Range, an old massif uplifted and deformed from Lutetian to Neogene times, is divided into mountain massifs, *Surco Prelitoral* (pre-littoral furrow) is a tectonic scar with fragments of Permian and Mesozoic rocks that contains almost all the

regional Tertiary record in discontinuous outcrops (La Espina, Grado, Oviedo, Infesto, ...) with a relative concordance of facies (Llopis Lladó & Martínez Álvarez, 1958, 1959, 1960; IGME, 1979-84, 1986; Truyols *et al.*, 1991).

The continental Tertiary deposits, up to 250 m thick, between Oviedo and Infesto rest upon the karstified top of Upper Cretaceous carbonate rocks. They can be divided into two units (Truyols *et al.*, 1991): a lower mud unit with yellow-red or grey-green sands is overlain by red-yellow clays and marls with calcareous sands and brecciated limestone rich in gastropods and ostracods of Oligocene age. To the north, these two units change laterally into calcareous gravels and breccias (*Pudinga de Posada*).

Three units have been differentiated in Grado:

- A lower fining-upwards sequence of conglomerates and sandstone with carbonate cement and laminated, burrowed muds of braided river origin.
- A thick intermediate coarsening-upwards unit of clay and laminated mud passing upwards into conglomerates and sandstone with intercalations of laminated, burrowed muds. This is interpreted as sediments of ephemeral river systems and flood-plain deposits including limestone and marls.
- The top of the section consists of alluvial-fan, massive gravel, supplied from the south.

The westernmost fragments of this Tertiary Asturias Basin occur isolated and perched high near Pola de Alande. They are alluvial-fan deposits that change upwards to fluvial facies; they are related to a structural line. The proximal fan facies are massive gravels with sands and burrowed muds; distal fan and fluvial facies consist of gravels, sands and green burrowed muds (IGME, 1986).

All these outcrops are the remains of a unique basin that extended from east to west with an active northern boundary (*Franja Móvil Intermedia*) which governed sedimentation and strongly influenced the terminal tectofacies (*Pudinga de Posada*). Faults broke up the outline of the basin and parts of it were eroded some time afterwards.

Stratigraphic correlation, fragmentation, Cainozoic variety and dispersion

As previously indicated, the Tertiary of the north-west is varied because it is located in several morphostructural positions, which are isolated from each other. Furthermore, outcrops are usually of very poor quality and the palaeontological record is scarce. As a consequence, correlation depends on a wide range of criteria which are not always equivalent: palaeontology, mineralogy and petrology, geomorphology, tectonics and comparison with better known and dated facies in regions nearby. As expected, the results lack homogeneity and contain notable discrepancies (Fig. 12).

Palaeontological data are scarce, frequently confused and in deep fluvial disagreement with other data; in fact these data play a negative role because they impose forced correlation. The reason is that the

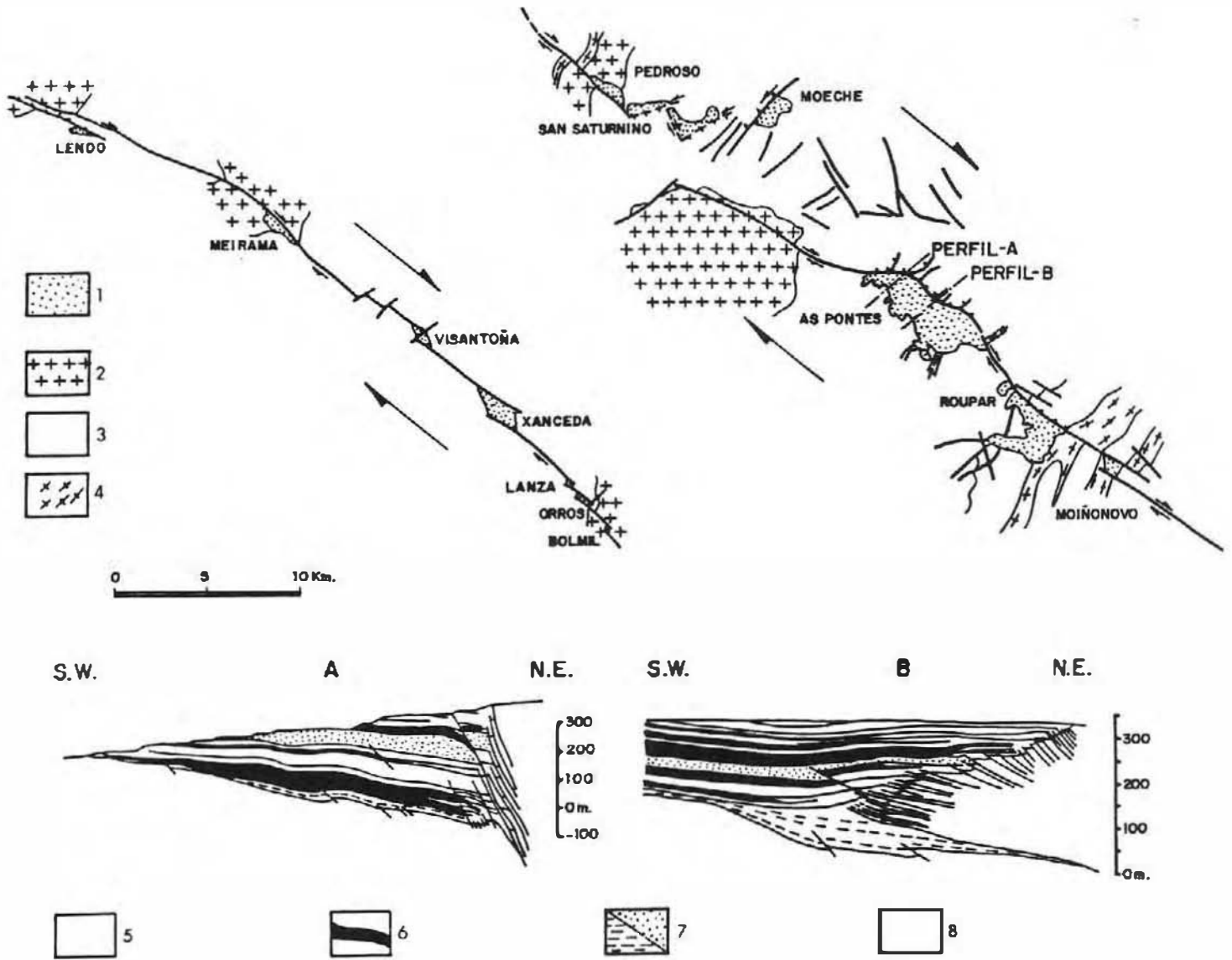


Fig. 5. Tectonic basins of Meirama and Puentes de Garcia Rodriguez with two transverse cross-sections (Perfil-A of sediments in Puentes de Garcia Rodriguez basin (from Bacelar *et al.*, 1988 and Santanuch *et al.*, 1988). 1: Cainozoic; Palaeozoic; 2: Igneous rocks; 3: Quartzites and slates; 4: Schists and other metasediments; 5: Palaeozoic basement; 6: Coal dominated interbedding (siliciclastic beds subordinated); 7: Siliciclastic alternances (without coal beds); 8: Coal-siliciclastics alternation.

palaeontological assemblages are poor: only some layers of vertebrates and charophytes near Oviedo, dated as Rhenanian-Headonian in age (Truyols *et al.*, 1991), and palynomorphs in lignitic beds in the Coruña basins, attributed to the Middle-Upper Miocene to Pleistocene (Medus, 1963; Nonn & Medus, 1963; Menéndez Amor, 1975; Maldonado, 1977; Araujo *et al.*, 1988). Recently, these sites also yielded vertebrates of Oligocene-Lower Miocene age (Esteban *et al.*, 1989).

The problem is that Cainozoic outcrops show a great variability of thickness, facies, sequential arrangement and petrologic and mineralogical composition. Such a diversity seems incompatible with the idea of a unique (and coeval) palaeogeography and

palaeoclimate as especially suggested by the basins in Galicia. In some areas, there are siderolithic facies and lignite (Atlantic basins), whereas in others, arkosic sediments dominate (Lugo basins). Is there a single geological background for all these basins? An affirmative answer implies that the age ranges between Upper Oligocene and Neogene and also requires an explanation for the diversity of facies in terms of local palaeogeographical and palaeogeomorphological features (Biro & Solé, 1954; Nonn, 1966; Breil & Doval, 1974). If the answer is negative, the diversity has to be explained as the result of stratigraphic superposition (Fig. 13), which implies discontinuous sedimentation in steps and a prolongation of the time-duration of the stratigraphic record (Martin-

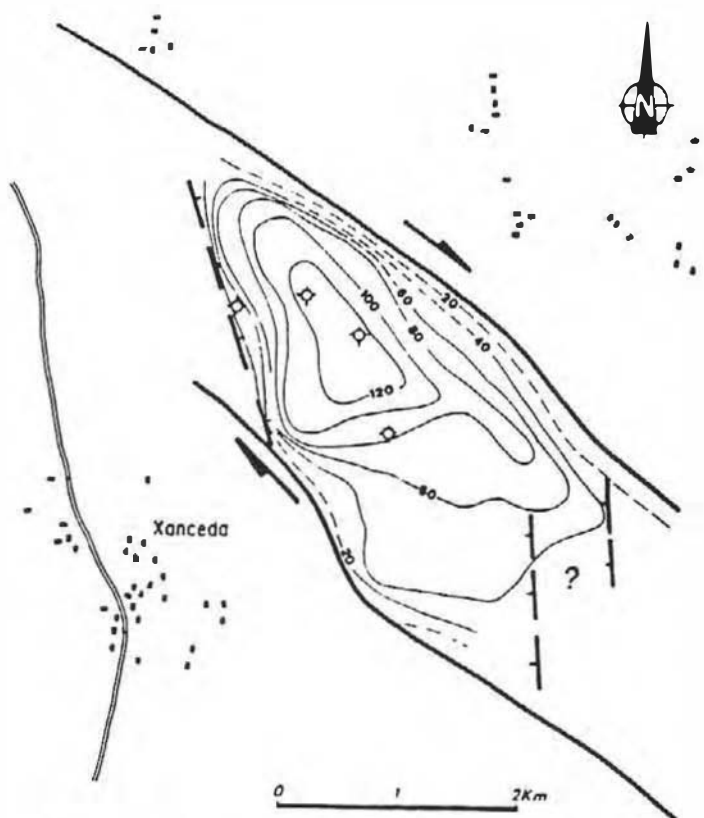


Fig. 6. Structural scheme of Xanceda Basin. Basement isobaths deduced from electric and mechanical vertical drillings (from Santanach *et al.*, 1988).

Serrano, 1982; Vergnolle, 1988). In this second mode, it is possible to correlate the basins of Galicia with the Duero Basin via the Bierzo Basins.

As with other major geological belts, the north-western Cainozoic basins were controlled by several fault systems leading to the analysis of the different basins on the basis of particular features. These features can be correlated to other lithostratigraphic or geomorphologic attributes, but these comparisons lead straight back to the basic problem: poor knowledge of the age and succession of geotectonic and geomorphologic events due to the poor chronostratigraphy of the associated sediments. On the other hand, erosion surfaces have been largely obliterated by faulting. For this reason, a confusing variety of geotectonic hypotheses have been proposed; for example: that the Pyrenean, Saavico or former Alpine phases were responsible for initial tilting and that more recent topographic changes and instability (evident through the Neogene) extends until Plio-Quaternary times.

This problem can only be overcome by the combination of geomorphologic, tectonic and stratigraphic studies. Systematic analysis should focus on geomorphologic investigation because, in these Tertiary studies, relief is not only the palaeogeomorphological context of the basins but also the result of the Alpine geotectonic framework. This approach makes it clear how important the study of weathering profiles, as 'alterites' is likely to be. These occur both

still resting upon the basement and also incorporated into the Tertiary sediments, because through time the main bulk of alterites must have been eroded and incorporated into the basin fills. Then it should be possible to compare sediments and weathering profiles and in consequence correlate them with planation surfaces. With a special link like the alterites, we can plan to correlate the lithostratigraphy of basins with the evolution of relief and vice-versa.

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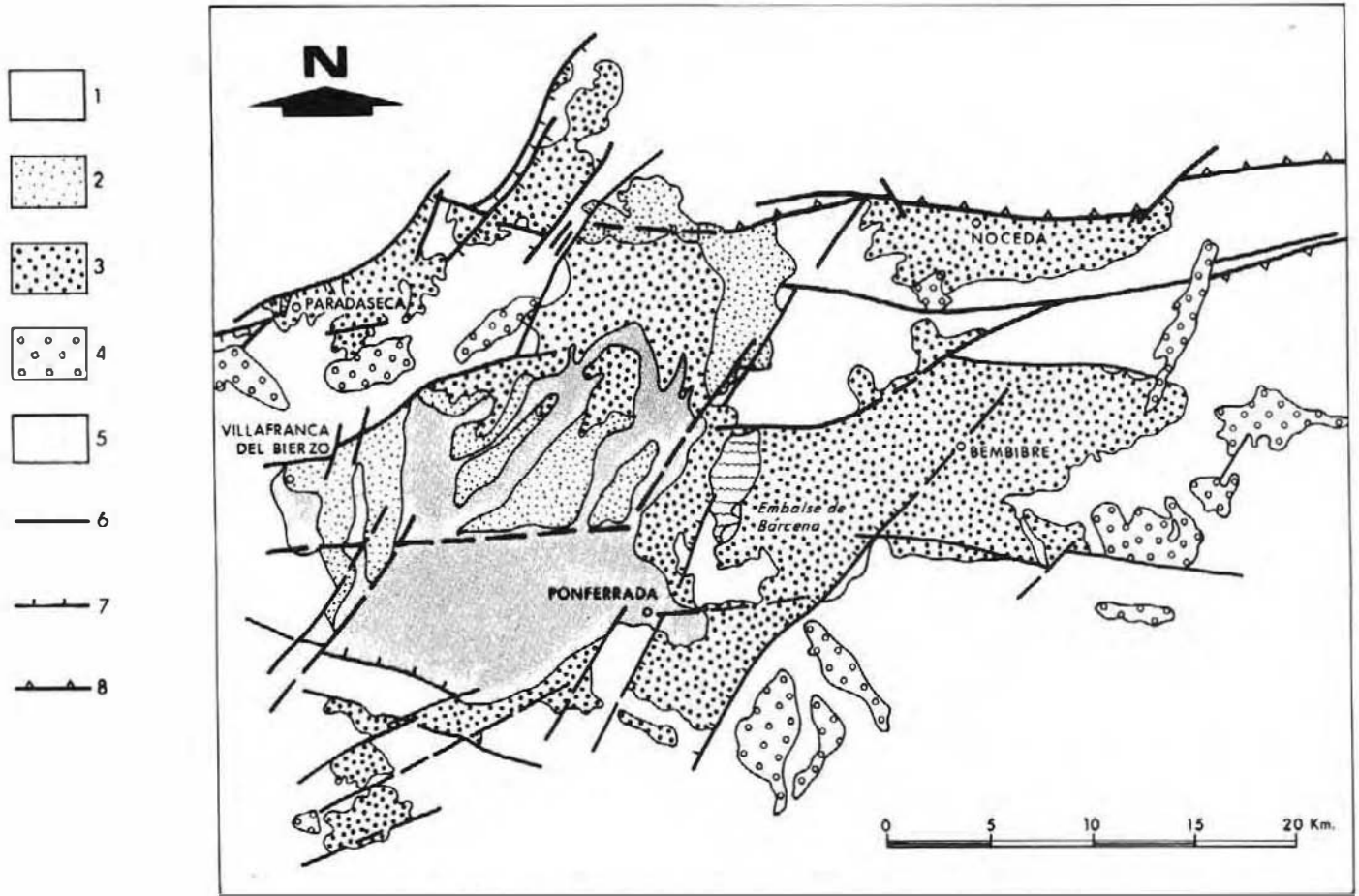


Fig. 7. Structure and sedimentation of Bierzo Basin (from Herail, 1984 and IGME, 1979-1984 and 1986). 1. Basement; 2. Toral Formation; 3. Santalla and Las Médulas Formation; 4. uppermost gravels; 5. terraces (Quaternary?); 6. faults; 7. normal faults; 8. reverse faults.

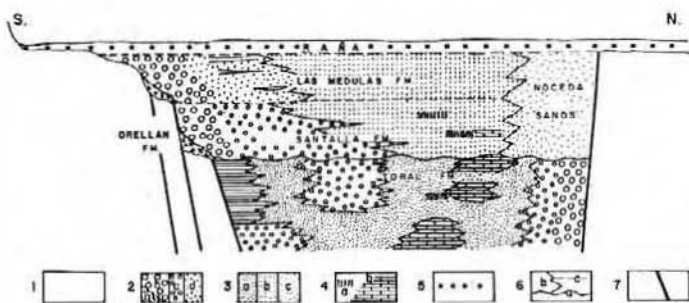


Fig. 8. Lithostratigraphy of the Bierzo Basin fill (from Herail, 1984). 1. Basement; 2. gravels: a. monogenic breccias; h. quartzite and sandstone blocks; c. rounded gravels; d. matrix-rich poor rounded gravels; 3. sandy, silty and muddy facies: a. smectite-rich, feldspar and quartzose sands; b. illite-rich, schist and quartzose sands; c. illite-rich, quartzose sands; 4. carbonates (limestones and dolostones): a. isolated concretions; h. massive and tabular levels; 5. *raña*, highly altered quartzite pebbles and blocks; 6. sedimentary discontinuity; a. discordance; b. lateral change of facies; c. vertical facies transition; 7. faults.

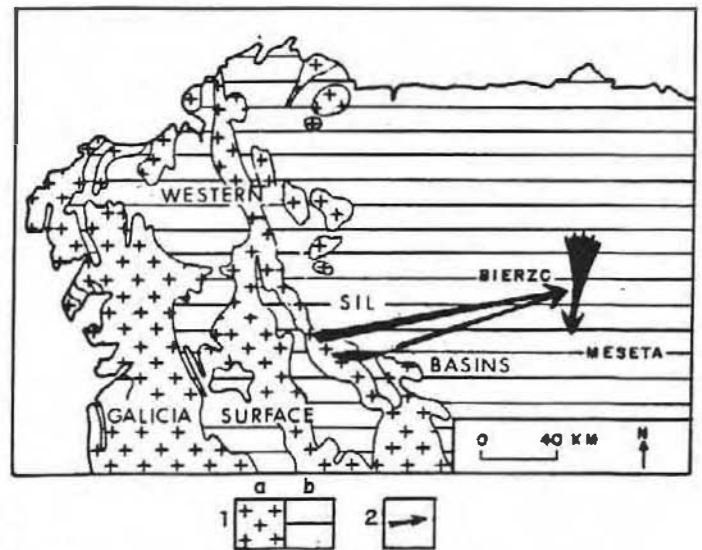


Fig. 9. Palaeocurrent directions measured in Lower Miocene deposits of north-western Iberian Peninsula (Vergnolle, 1988). 1. Basement: a. granitoids; b. metamorphic rocks; 2. palaeocurrents.

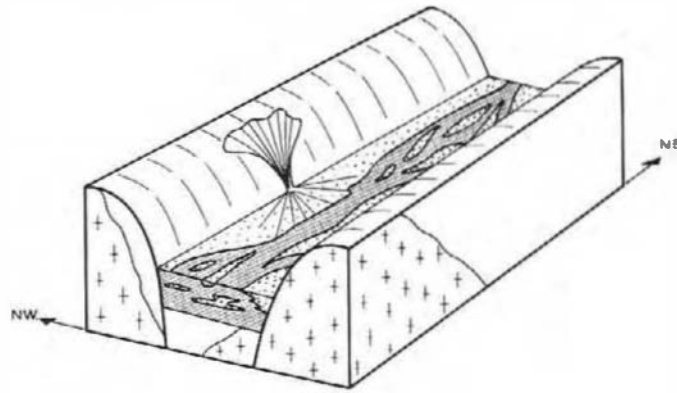


Fig. 10. Palaeogeographical scheme for Quiroga Formation (from Vergnolle, 1988).

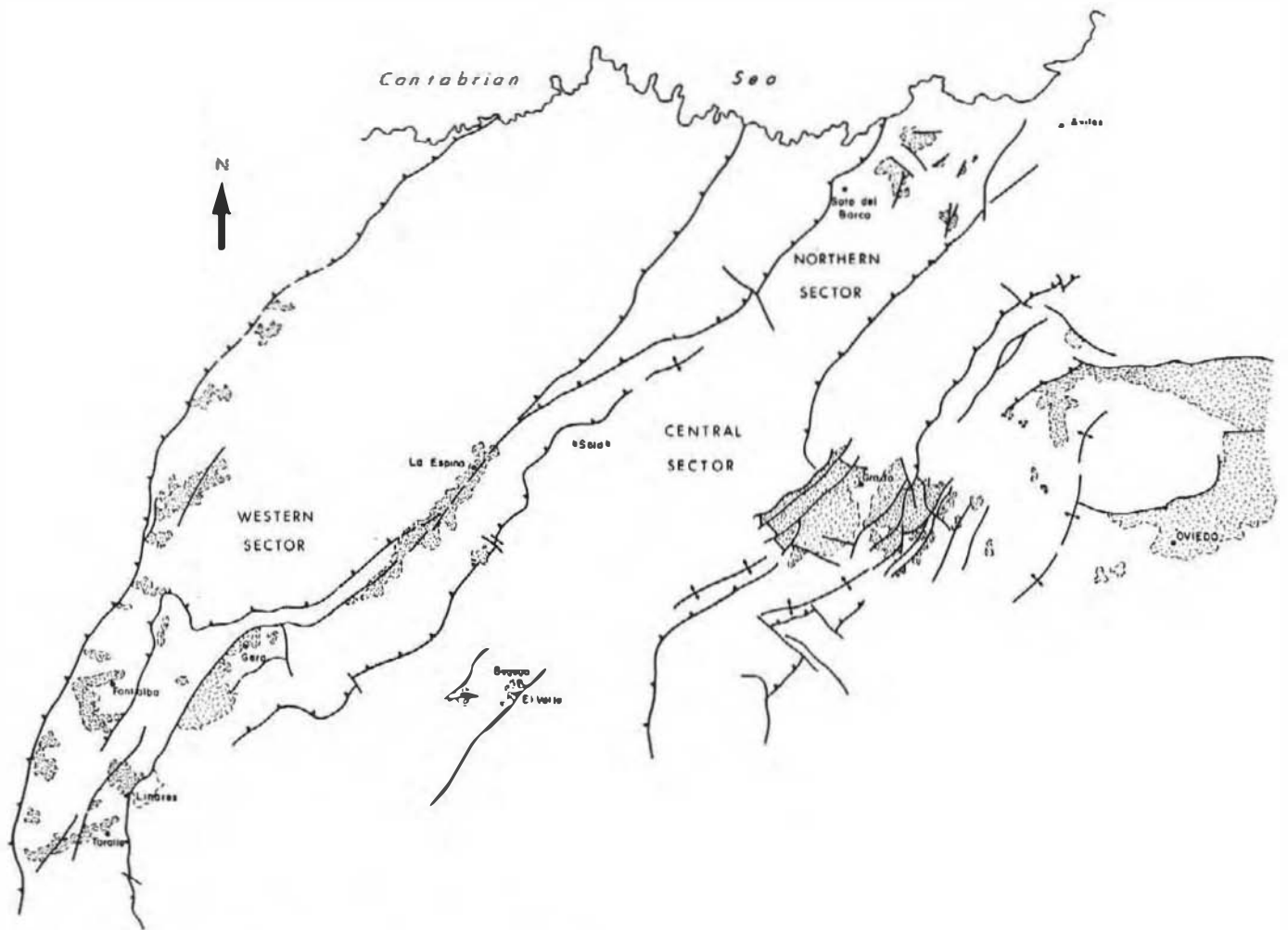


Fig. 11. Tertiary outcrops in western Asturias (IGNIE, 1979-1984).

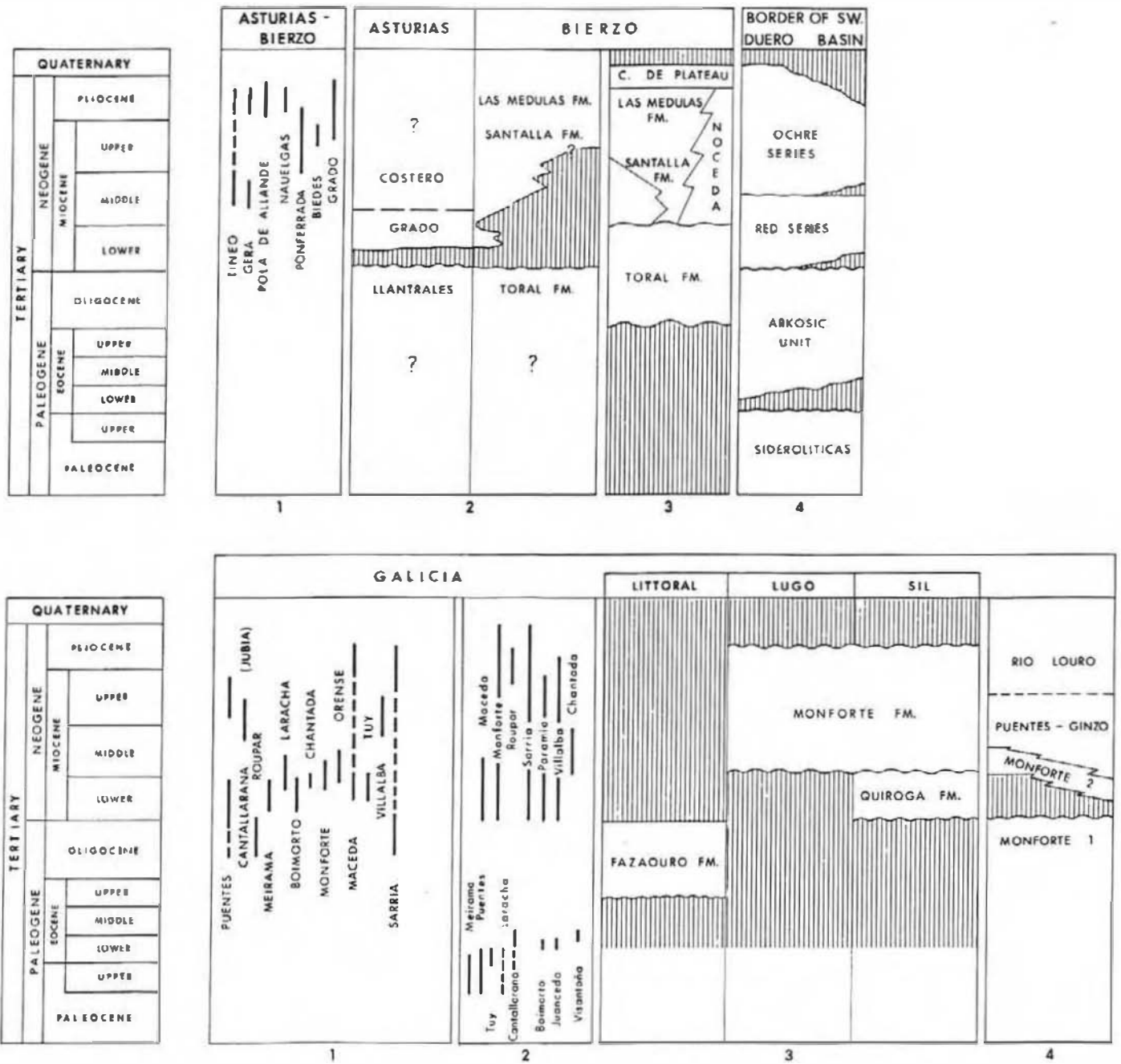


Fig. 12. Chronostratigraphy of Tertiary deposits in north-western Iberian Peninsula. Upper table: 1. Brell & Doval (1974); 2. IGME (1986); 3. Herai (1984); 4. Santisteban *et al.* (1991). Lower Table: 1. Brell & Doval (1974); 2. Martin-Serrano (1982); 3. Vergnolle (1988); 4. IGME (1986).

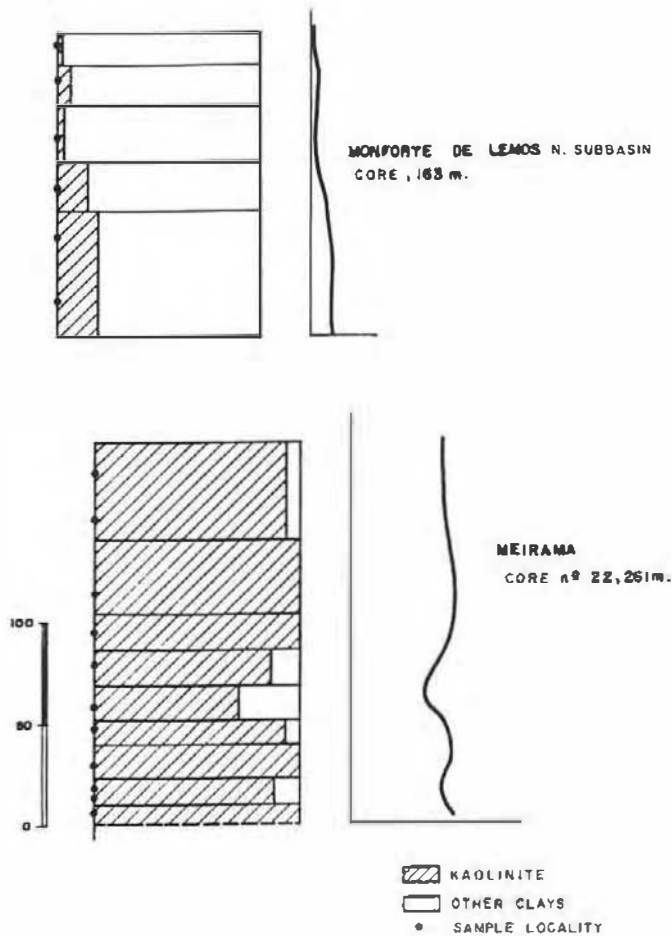


Fig. 13. Kaolinite proportion in clays of two different Galicia basins (data for Meirama Basin from Maldonado, 1977; and data for Monforte de Lemos from Promotora de Recursos Naturales, 1978).

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