LEIDSE GEOLOGISCHE MEDEDELINGEN, Vol. 41, pp. 221—228, published separately 15-7-1968

LITHOSTRATIGRAPHIC SUBDIVISION OF POST-HERCYNIAN DEPOSITS IN THE SOUTH-CENTRAL PYRENEES, SPAIN

BY

P. H. W. MEY, P. J. C. NAGTEGAAL, K. J. ROBERTI AND J. J. A. HARTEVELT *)

INTRODUCTION

On the existing geological maps of the South-Central Pyrenees such as those of Dalloni (1910, 1930), Misch (1934), Almela & Rios (1947) and Alastrue, Almela & Rios (1957) the units distinguished and the colours used represent stratigraphic time intervals. Many stage boundaries, however, fall at levels which may lie anywhere in a homogeneous rock sequence. To overcome this difficulty the practice up to now has been to substitute the nearest marked lithological change for the unmappable time-stratigraphic limit. This simplification hardly matters in small-scale geological maps (scales of 1 : 175,000 and 1 : 200,000). The errors introduced become unjustifiable, however, when mapping on scales of 1 : 10,000 to 1 : 50,000. Pronounced facies changes and diachronism as have been shown to apply to many of the deposits under consideration (Souquet, 1967), add a further complication.

Mapping of the Central Pyrenees has been undertaken by the Geological Institute of the University of Leiden and to date the first six, 1 : 50,000, map sheets of the projected series of ten maps have been published. In the course of field studies carried out by the present authors in the South-Central Pyrenees, a lithostratigraphic subdivision was developed which is here published in a condensed form. The subdivision is largely based on physical criteria, recognizable in the field. The units distinguished are formations in the sense of the Code of Stratigraphical Nomenclature (1961).

The formations are named and the boundaries are given. The corresponding ages and lateral relationships are shown in Table 1.

Detailed lithological descriptions, sedimentary and palaeontologic analyses will be published in the memoirs accompanying the geological map sheets 7, 8, 9, 10 (Fig. 1) by the Department of Structural Geology, and in forthcoming articles by members of the Department of Sedimentology.

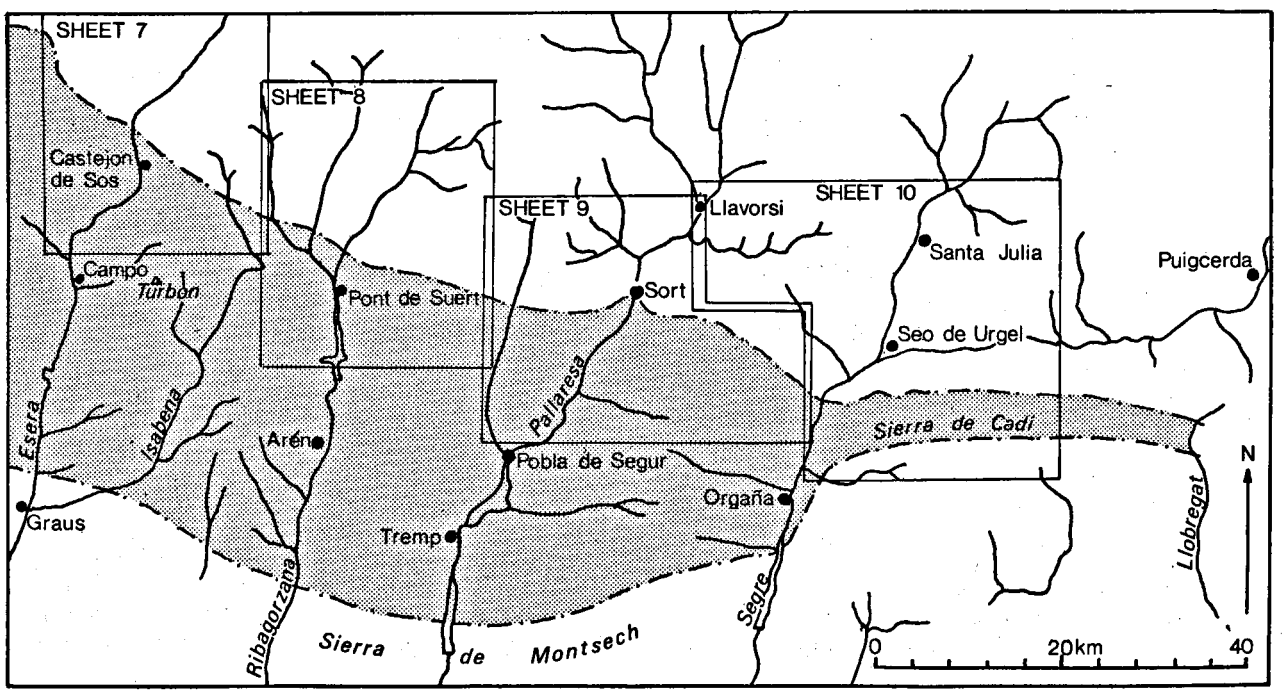

Fig. 1. Reliability sketch-map showing the region (shaded) over which the formations discussed apply together with the outlines of the map sheets.

*) Geological Department of the University of Leiden, the Netherlands.

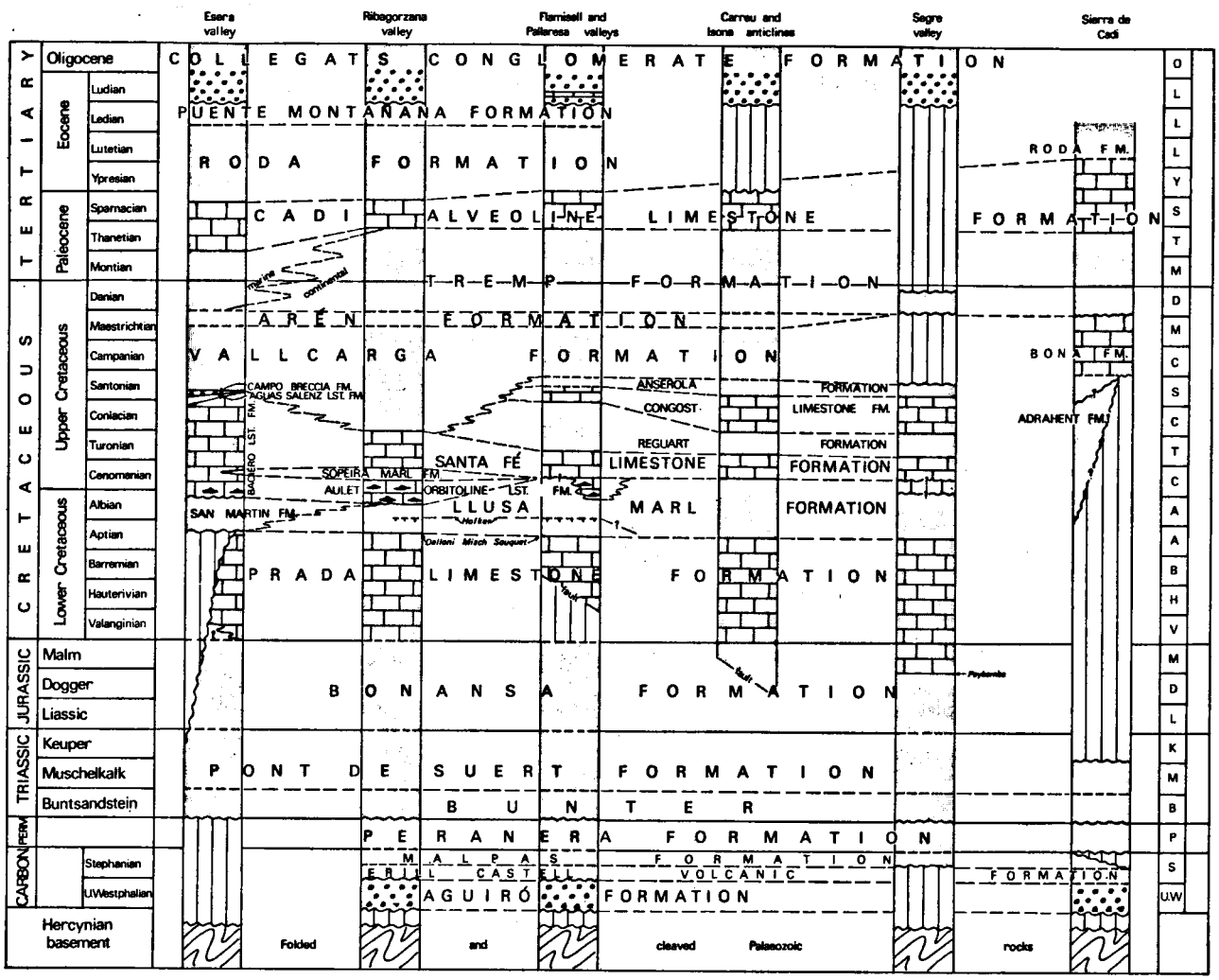

Table 1. Post-Hercynian formations in the South-Central Pyrenees, between the rivers Esera and Llobregat.

I. POST-HERCYNIAN, UPPER PALAEOZOIC DEPOSITS

The post-Hercynian, Upper Palaeozoic deposits in the area of study (Fig. 1) are strictly non-marine and largely fluvial. Volcanic deposits (Erill Castell volcanics) occur on top of strata dated as Westphalian D (Aguiró Formation) and below strata having a Stephanian age (Malpas Formation). Only a few levels have yielded fossils, mainly in the form of plant imprints (Dalloni, 1910, 1930).

Aguiró Formation (Westphalian D)

The formation has been named after the village of Aguiró (sheet 9, coord. 42°24′. 4°38′ east of Madrid), several hundred metres west of which occurs a well-exposed and characteristic section.

The Aguiró Formation is composed of mainly coarse conglomerates with locally, at the base, a horizon of breccia and some coal stringers. It rests unconformably on folded and cleaved Lower Carboniferous and older rocks. The upper boundary is drawn at the base of the first pyroclastics (Erill Castell volcanics).

Erill Castell Volcanic Formation (Stephanian)

The formation is named after the small village of Erill Castell (sheet 8, coord. 42°25½′. 4°29½′), in the surroundings of which this formation is complete and well-exposed.

The Erill Castell Volcanic Formation is composed of mainly light-coloured tuffs containing bombs of up to 1 m, which in the Erill Castell-Peranera area are overlain by a dark-green, massive basaltic-andesite sheet. The lower boundary is drawn at the Hercynian unconformity or, as in the Castelnou-Aguiró area, at the contact with the conglomerates of the Aguiró Formation. The upper boundary is drawn either at the contact with the detrital sediments of the Malpas Formation or at the red-coloured Peranera Formation.

Malpas Formation (Stephanian)
The formation has been named after the village of Malpas (sheet 8, coord. 42°24½'. 4°29'), close to the Malpas coal mines. In that area the formation as well as the intercalated coal seams are thickest. The Malpas Formation comprises a series of dark-grey and brownish fluvial sediments with intercalations of coal seams of up to 2 m thickness, and some carbonate beds.
The lower boundary is either the contact with the Erill Castell volcanics (e.g. area between the rivers Tor and Pallaresa) or the unconformity on Hercynian folded rocks (e.g. Segre valley). The upper boundary is drawn where colours change from dark-grey to greyish-red (Peranera Formation).

Peranera Formation (Permian)
The formation has been named after the Peranera River (sheet 8, coord. 42°23½' — 42°26½'. 4°28½' — 4° 30½'). In the Peranera valley the formation is thin but typical and here both the lower boundary and the unconformable relation with the overlying Bunter are clearly exposed.
The Peranera Formation consists of a monotonous greyish-red alternation of calcareous mudstones, siltstones, sandstones, and tuffs, transported tuff material, breccia beds and nodular limestone/dolomite beds.
The lower boundary is generally a conformable contact with the Erill Castell volcanics or with dark-coloured shales and sandstones of the Malpas Formation. Locally the Peranera Formation lies unconformably on Hercynian folded rocks (e.g. Rubio area, sheet 9, coord. 42°22½'. 4°54½') or unconformably on the Erill Castell volcanics (e.g. South of Seo de Urgel).
The upper boundary is drawn at the sharp contact with the first coarse quartz-sandstone or pebble-bed belonging to the Bunter. In many areas this contact is a conspicuous unconformity, its angle varying from 10° to about 30° locally.

II. MESOZOIC DEPOSITS

The Mesozoic deposits start with fluvial red beds of the Bunter, but the overlying deposits are all marine, mostly limestones. The uppermost Mesozoic was a period of regression; near-shore and fully continental deposits are of widespread occurrence (Arén Sandstone Formation, Tremp Formation).

Bunter (Lower Triassic)
For this Lower Triassic rock unit with its very uniform development over large parts of the European continent the introduction of a local geographic name would be undesirable. The name Bunter (Buntsandstein) is used as a formation as done by many authors.
The Bunter consists of a predominantly greyish-red sequence of conglomerates, coarse-grained quartzose sandstones, silt- and mudstones, the medium-grained rocks commonly being micaceous.
The lower boundary is nearly everywhere an angular unconformity on rocks ranging in age from Ordovician to Permian. The upper boundary is drawn at the contact of reddish, greenish or dark-grey shales of the uppermost Bunter with dolomitic marl, gypsum or limestone/dolomite; this contact is, however, often faulted.

Pont de Suert Formation (Middle and Upper Triassic)
The formation is named after the village of Pont de Suert (sheet 8, coord. 42°24½'. 4°26'), in the vicinity of which occur several well-exposed, only little disturbed and almost complete sections.
The Pont de Suert Formation consists of dark-greyish to black micritic limestone, fine-grained dolomite, grey, red and green dolomitic marls, cavernous dolomite and vividly-coloured gypsum and rock-salt. Bodies of crystalline basic rock (ophite) generally occur in mainly the gypsiferous part of the formation. Almost invariably the lower as well as the upper boundaries of this formation are tectonically disturbed. In the rare outcrops where an undisturbed transition from the Bunter is present the lower boundary has been drawn at the base of yellowish dolomitic marl, gypsum or limestone/dolomite lying above dark-grey, greenish or reddish shales of the uppermost Bunter. When not faulted or truncated by an unconformity the upper boundary is the contact of gypsum, dolomitic marl or cavernous dolomite with a competent carbonate unit in which thinly stratified, non fossiliferous marly and dolomitic limestones and dolomites alternate (Bonansa Formation).

Bonansa Formation (Lias-Dogger)
The formation is named after the village of Bonansa (sheet 8, coord. 42°25½'.4°21') 2½ km east of which a very well-exposed continuous outcrop occurs along the road.
The Bonansa Formation consists in its lower part of a competent, fine-grained carbonate unit in which alternate thinly-stratified marly and dolomitic limestones and dolomites, the latter locally being cavernous. The central part contains dark shales, marls and marly, very fossiliferous limestones and is followed by a competent, coarse-grained sequence of mainly massive dolomites with a characteristic dark-grey to black weathering.
The lower boundary of this formation is most often faulted, but when undisturbed it is drawn at the base of a competent carbonate unit below which occur gypsum or dolomitic marl which may locally be cavernous.
The transition into the overlying Prada Formation is rather gradual, but the boundary is drawn at the top of a sequence in which dolomites dominate over limestones.

Prada Limestone Formation (Malm-Upper Aptian: „Urgonian")
The formation is named after the Sierra de Prada (sheet 9, coord. 42°15'.4°55°—5°02'), a limestone mountain ridge west of the Segre River. A very thick

and characteristic section is exposed along the road from Orgaña to Seo de Urgel.
The Prada Limestone Formation is a massive, dark-grey to black, fossiliferous and predominantly micritic rock sequence overlying the Bonansa Formation. In its lower part dolomitic and breccious intercalations abound, and in its upper part occur some intercalations of marly limestone and marl.
The transition from the underlying dolomites of the Bonansa Formation is gradual, but the boundary is drawn at the base of a sequence in which limestones exceed dolomites. The upper contact may be gradational and then the boundary is chosen where limestones lose their dominance over marls.

Llusa Marl Formation (Upper Aptian-Lower Cenomanian)
The formation is named after the hamlet Llusa in the Flamisell valley (sheet 9, coord. 42°18½'.4°38'), which is surrounded by a well-exposed and typical sequence of these marls.
The Llusa marls consist of a greyish, monotonous alternation of fossiliferous shaly marls and silty marls (often nodular) with only a few intercalations of marly limestone.
The lower boundary of the Llusa marls is rather sharp in the eastern areas, where the marls rest with an abrupt but conformable contact upon the black limestones of the Prada Formation. In the central and western areas, however, there is a passage from relatively pure limestones of the Prada Formation with increasing argillaceous content into the Llusa marls.
The upper boundary of the marl formation is in many areas a slight angular unconformity and then consequently the boundary with the overlying limestones or sandy limestones is very sharp. Where no such unconformity is present the upper boundary of the formation is drawn at the contact between marls and a relatively more competent, coarse bioclastic limestone unit characterized by an abundance of orbitolines (Aulet Formation) or at the contact between marls and a micritic limestone characterized by an abundance of prealveolines (Santa Fé Formation). West of the Ribagorzana valley this marine sequence of mainly marls grades laterally into deposits characterized by mainly sandstones and coal beds (San Martin Formation).

San Martin Formation (Albian)
The formation is named after the village of San Martin in the Nogueras Zone (sheet 7, coord. 42°28'.4°12'). In the San Martin Formation alternate light-coloured quartz-sandstones, quartz conglomerates, shaly oyster-rich marls, coal seams and a few thin-bedded bituminous black limestones. Locally only sandstones and conglomerates are developed.
Generally the lower boundary is an unconformity, the formation resting with a sharp contact on rocks of the Prada, Bonansa or Pont de Suert formations. Frequently the upper boundary is also an unconformity, the base of the overlying Baciero Formation being a fragmental, light-grey limestone or a yellowish to reddish sandy orbitoline limestone.
The San Martin Formation is the lateral equivalent of the Llusa marls.

Aulet Orbitoline-Limestone Formation (U.Albian-L.Cenomanian)
The formation is named after the Sierra de Aulet (coord. 42°19½'.4°23' - 4°27'), an E-W-striking mountain ridge formed by a very thick (almost 900 m) sequence of these limestones, in which the Ribagorzana River carved a narrow gorge. In the upstream part of the gorge the Escales gravity-dam has been constructed.
The Aulet Orbitoline-Limestone Formation mainly consists of a yellowish to reddish-brown coloured, coarse-grained bioclastic limestone with an abundance of orbitolines. The limestones, apart from being breccious and dolomitic, are generally sand-bearing (except in the Pallaresa valley) and alternate with dark-coloured marls and marly limestones.
The transition from the underlying Llusa marls is gradual; the boundary is taken at the base of a competent sequence in which orbitoline-bearing limestones dominate over marls. The contact is sharp and unconformable in the area west of the Ribagorzana, where the Aulet Formation overlies sandstones and conglomerates of the San Martin Formation.
The upper boundary of the Aulet Formation is drawn at the top of the last massive limestone, which generally is still orbitoline-bearing.
In the type section the orbitoline limestones are overlain by the nodular Sopeira marls, but in the Bonansa area, in the Sierra de San Gervás and in the Pallaresa valley they are overlain by the grey micritic limestones with prealveolines of the Santa Fé Formation. In the Turbón area and west of it the orbitoline limestone forms the lower part of the Baciero Limestone Formation, but there it can only occasionally be mapped as an individual unit.

Sopeira Marl Formation (Upper Cenomanian)
The formation is named after the village of Sopeira in the Ribagorzana valley (coord. 42°19'.4°26') which is built in a depression several hundred metres wide between the Aulet limestone in the north and the Santa Fé limestone in the south. The occurrence of this formation is restricted to the Ribagorzana and Isabena valleys.
The Sopeira Marl Formation consists of a light-coloured sequence in which alternate regularly and thinly-bedded sandy marls and nodular argillaceous limestones, spotted with glauconite and pyrite. An abundance of echinoids and ammonites is characteristic.
The lower boundary of the formation is taken at the base of a nodular sequence in which marls and marly limestones dominate over massive bioclastic limestones characterized by an abundance of orbitolines (Aulet Formation).

The upper boundary is taken at the top of a nodular sequence in which marls and marly limestones dominate over more massive micritic limestones with an abundance of prealveolines (Santa Fé Formation).

Santa Fé Limestone Formation (Upper Cenomanian-Turonian)
The formation is named after the Peña de Santa Fé (coord. 42°12½'.4°59½'), an impressive mountain which is crowned by a shallow syncline of Upper Cretaceous limestones. The Santa Fé limestone is the highest individual limestone unit, about 20-40 m thick, which lies just below the steep upper scarp formed by the thicker Congost limestone.
The Santa Fé Limestone Formation is a competent limestone unit composed of a light-grey to beige micritic carbonate, characterized by an abundance of prealveolines and miliolids. The upper part of the formation, in which fissurines and globigerines abound, is generally marly. In the Ribagorzana valley the middle and upper part of the formation is strongly slumped and brecciated; in the Flamisell valley one slump horizon has been observed in the upper part. This strongly transgressive formation lies with a sharp, but probably conformable contact upon Llusa marls east of the Flamisell valley (except for the Pallaresa valley, where it overlies the Aulet Orbitoline Limestone). West of the Flamisell valley and east of the Turbón it rests with a rather sharp but conformable contact on nodular marls of the Sopeira Formation. In the Turbón area and the Esera valley neither the lower nor the upper boundary is mappable continuously. Still further to the west the lower boundary becomes a conspicuous unconformity above Permo-Triassic or Palaeozoic rocks.
The transition into the overlying Reguart Formation may be a sharp but conformable contact between pure micritic limestones below and marls above, but may also be gradual, the top then being drawn above a competent sequence in which pure limestones dominate over marls and argillaceous limestones. In the Ribagorzana valley the micritic limestone of the Santa Fé Formation is conformably overlain by slumped marls and graded marly limestones (Vallcarga Formation).

Reguart Formation (Turonian-Coniacian)
The formation is named after the hamlet of Reguart in the Flamisell valley (sheet 9, coord. 42°18'.4°38'), southwest of which an easily accessible and typical sequence of mainly marls and nodular limestones is exposed.
The Reguart Formation consists of a regular, grey sequence in which alternate shale, shaly marl and nodular argillaceous limestone.
The transition into both under- and overlying limestones is commonly gradual. The lower boundary is drawn where marls and argillaceous limestones exceed micritic limestones (Santa Fé Formation). The upper boundary is drawn where nodular marls give way to massive limestones (Congost Formation).

Congost Limestone Formation (Coniacian-Santonian)
The name of this formation is derived from the narrow gorge in these rocks about 5 km north of Pobla de Segur, through which the Flamisell River has made its way (sheet 9, coord. 42°17'.4°37½'). This formation wedges out west of the Flamisell River.
The Congost Limestone Formation is a complex light-grey limestone unit, consisting of micritic limestones, coral and algal limestones (small bioherms), reef talus and argillaceous limestones. Locally the limestones are glauconitic and/or sandy. A bed with *Hippuritus* is frequently developed at the top.
The contact of this formation with the underlying argillaceous carbonates is generally gradual; the boundary is drawn where pure limestones exceed marls and nodular argillaceous limestones (Reguart Formation). The upper boundary is taken where the pure limestones are conformably succeeded by a sequence of mainly nodular argillaceous limestones in which echinoids abound (Anserola Formation).

Anserola Formation (Santonian)
The formation is named after a small tributary of the Flamisell River, running in the strike of these rocks just southwest of the above mentioned Congost-gorge (sheet 9, coord. 42°17'.4°34½'-4°37½').
The Anserola Formation consists mainly of an alternation of shaly marls and nodular argillaceous limestones in which echinoids abound. A high content of glauconite is characteristic for this rock unit. In the upper part of the formation slump structures are frequently found.
The lower boundary is a rather sharp contact with the Congost limestone. The transition into the overlying Vallcarga Formation is gradual, but the boundary is taken at the base of the first turbidites and/or mudflows.

In the area west of the Isabena River the entire lower part of the upper Cretaceous (Cenomanian-Santonian) is developed as a limestone, in which only locally slightly marly intercalations can be mapped separately. In that area (sheet 7) the entire carbonate complex above the San Martin Formation and below the Vallcarga Formation is called the Baciero limestone (Wennekers, 1968).

Baciero Limestone Formation (Cenomanian-Santonian)
The formation is named after the Sierra de Baciero east of the Esera River (sheet 7, coord. 42°27½'.4°09'), where these limestones form a steep mountain ridge. This formation is restricted to the area west of the Isabena River.
The Baciero Limestone Formation is defined as a complex limestone unit, whose lower part is a grey and reddish, orbitoline-bearing, locally sandy, coarse bioclastic limestone, occasionally followed by a horizon of a very fine-grained argillaceous limestone with a nodular habit.
The upper part is formed by a dark-grey coarse

bioclast, which may be sandy or even conglomeratic and which contains a mappable horizon with black chert concretions.
The lower boundary is everywhere an unconformity on top of sandstones of the San Martin Formation. The upper boundary may be a sharp contact between silty limestones below and marls with slumps above (e.g. south of the Congosto de Ventamilla, coord. 42°29′-42° 30′.4°08′-4°09′) or a gradual transition into the argillaceous, bituminous carbonates of the Aguas Salenz Limestones (south of the Baciero), the boundary then being drawn below a sequence which contains far more argillaceous limestones than pure limestones.

In the Esera valley and south of the Sierra de Baciero two formations have been reported (Misch, 1934; Souquet, 1967; Wennekers, 1968), but the correlation with the rock units further to the east is so far not clear and they will not yet be defined here. Both formations have a Santonian age (Souquet 1963, 1964).
The lower one of these units, the *Aguas Salenz Limestones*, is a very regularly and thin-bedded sequence of dark-grey to black argillaceous limestones with a total thickness of at least 1500 m. In an eastward direction they grade into grey, nodular limestones, somewhat comparable to the Anserola Formation. The transition into the underlying Baciero limestone is gradual.
The overlying breccia, the *Campo Breccia*, has a sharp and sometimes unconformable lower boundary. The formation is characterized by coarse limestone breccias with elements varying in size from several centimetres to several metres. Frequent are intercalations of slumped beds of siltstone, marl or calcarenite. The maximum thickness is about 400 m.
The transition into the overlying Vallcarga Formation, which in the lower part still contains thin breccia beds and thick horizons of slumped calcarenites, is gradual.

Vallcarga Formation (Santonian-Maestrichtian)
The formation is named after the small tributary of the Pallaresa River just north of Pobla de Segur (sheet 9, coord. 42°15½′-42°16½′. 4°39½′). In this streamlet an almost complete section of the lower part of the Vallcarga Formation is exposed.
The Vallcarga Formation consists in its lower part of characteristically yellow-brownish weathered turbidites (containing quartz and calcareous fragments of strongly varying coarseness). The middle part of the formation contains mudflows and olistostrome levels; in the upper part homogeneous bluish-grey marls predominate. Glauconite and wood fragments are characteristic components of the entire formation.
The lower boundary is drawn below the first mudflows and/or turbidites on top of a sequence of nodular limestones (Anserola Formation) or on top of thick limestone-breccia beds (Campo Breccia).
In the Ribagorzana valley the Vallcarga Formation lies with a sharp contact on the micritic limestones of the Santa Fé Formation.
The upper boundary of the formation is taken at the contact of the bluish-grey homogeneous marls (upper member of the Vallcarga Formation) with a thick sequence consisting mainly of coarse-grained calcarenites.

In the area east and south of the Segre River are two formations, of which the upper one, the Bona Formation, can be correlated with the Vallcarga Formation. The underlying rock unit of sandstones and conglomerates, the Adrahent Formation, rests with an unconformable contact on rocks of the Pont de Suert and Bonansa Formations. Guérin-Desjardins et Latreille (1961), who called this rock unit the "Série d'Adrahent", suggested a Santonian age for it, but the formation probably can have any age between Jurassic and Campanian.
A correlation with the San Martin Formation of Albian age is thus one of the possibilities. Both formations will be defined below.

Adrahent Formation (Albian? — Santonian?)
The formation is named after the village of Adrahent south of Seo de Urgel (sheet 10, coord. 42°16½′. 5°11′), in the vicinity of which a typical development is found.
The Adrahent Formation consists of white quartz conglomerates, sandstones and occasionally thin shale intercalations. Plant remains, so far indeterminable, may occur throughout the entire formation.
The lower boundary is an unconformity, the rocks of this formation resting with a sharp contact on those of the Pont de Suert Formation in the north and on the Bonansa Formation in the south. In the Sierra de Cadi this Adrahent Formation is overlain by limestones of the Bona Formation.

Bona Formation (Campanian-Maestrichtian)
The formation is named after the streamlet Bona southeast of Seo de Urgel (sheet 10, coord. 42°16′-42° 17′.5°11′-5°12′), the upper course of which forms a narrow gorge in this limestone unit.
The Bona Formation consists of bioclastic limestones, which are highly fossiliferous (mainly rudists). The deposits locally are marly or sandy; the latter especially at the base.
At the western extremity of the Sierra de Cadi the lower boundary is taken below the first sandy limestones resting on the pure sandstones of the Adrahent Formation, this contact being an unconformity. The lower boundary of this formation is also an unconformity in the eastern part of the Sierra de Cadi, but there the underlying formations range from the Erill Castell volcanics to the Pont de Suert Formation.
The upper boundary is taken at the sharp, probably unconformable contact of the limestones with the red-coloured mudstones or black shales of the Tremp Formation.

Arén Sandstone Formation (Maestrichtian)
The name of this formation has been derived from the village of Arén in the Ribagorzana valley (coord. 42°15½'.4°24½'). The name "*Arén Sandstone*" for this rock unit has been widely used before in the literature.
The Arén Sandstone Formation consists in its lower part of coarse-grained calcarenites and marls, and in its upper part of fine to coarse-grained, well-sorted quartz-bearing calcarenites, usually showing large-scale cross-bedding.
The lower boundary of the formation is drawn immediately below the first coarse-grained calcarenite, often glauconitic, resting on the thick marl sequence of the upper member of the Vallcarga Formation.
The upper boundary is taken at the sharp contact between calcarenites and a vividly coloured sequence of mudstones and sandstones (e.g. in the Ribagorzana valley), or a dark-grey sequence containing shales and non-marine limestones (e.g. Isona). These overlying rocks belong both to the Tremp Formation.

Tremp Formation (Upper Cretaceous-Lower Paleocene)
The formation is named after the small town of Tremp in the Pallaresa valley (coord. 42°10'.4°35'), in the surroundings of which many good exposures occur.
The Tremp Formation contains in its lower part black shales, coal beds and non-marine limestones (e.g. Isona) and in its upper part reddish-brown conglomerates, sandstones and mudstones, non-marine limestones and gypsum beds.
The lower part, as mentioned above, is not developed in the Ribagorzana valley.
The lower boundary is drawn at the base of black shales or red mudstones, which rest with a sharp contact on either calcarenites/sandstones of the Arén Formation or on the marine limestones of the Bona Formation, or, west of Orgaña (Segre valley), unconformably on the nodular limestones of the Anserola Formation.
The upper boundary is taken at the top of the uppermost red mudstones or, if limestones predominate in the upper part, at the top of limestones in which alveolines are rare or absent. The formation is overlain by limestones in which alveolines abound (Cadi Formation).
The marine equivalent of the Tremp Formation in the Isabena valley and west of it will be defined in a later publication.

III. TERTIARY DEPOSITS

In the Tertiary a major transgression is recorded by the marine Alveoline limestones and the Roda Formation, on top of which a depositional regression followed (Puente Montañana Formation). After the Pyreneic phase of the Tertiary orogenesis (pre-Ludian) extensive sheets of conglomeratic piedmont deposits were formed (Collegats conglomerates).

Cadi Alveoline-Limestone Formation (Thanetian-Lutetian)
The formation is named after the Sierra de Cadi (sheet 10, coord. 42°17'.5°11'-5°25'), the steep mountain ridge just southeast of Seo de Urgel, dominating the Upper Segre valley; the Cadi Formation forms the crest of this mountain ridge.
The Cadi Alveoline-Limestone Formation consists mainly of limestone sometimes argillaceous with an abundance of alveolines and nummulites.
The lower part may be developed as a limestone and quartz conglomerate with forams in the matrix. The top of the formation can be sandy and even sandstones may occur.
The lower boundary of this transgressive formation is put at the base of the conglomerates or limestones in which alveolines abound. It rests on the reddish coloured, mainly detrital rocks and limestones without or with only a few alveolines of the Tremp Formation.
The top of the formation is a gradual transition towards the bluish-grey marls of the Roda Formation.

Roda Formation (Sparnacian-Lutetian)
The formation is named after the village of Roda de Isabena (coord. 42°17½'.4°13') where various good sections are found.
The Roda Formation consists largely of medium-grey to dark-grey calcareous claystones between which thin calcarenite beds are intercalated. Both litho-facies may contain numerous marine microfossils.
The lower boundary is drawn at the base of the first claystone resting conformably on the limestones of the Cadi Formation. The Roda Formation shows a gradual transition into the overlying Puente Montañana Formation; the upper boundary is drawn at the point where colours change from grey to brownish,coinciding with the change from a marine to a continental facies.

Puente Montañana Formation (Ledian)
The formation is named after the village of Puente Montañana (coord. 42°09½'.4°22') in the surroundings of which no complete section, but many exposures are found.
The Puente Montañana Formation consists of brownish-grey to grey claystones and mudstones often containing calcareous concretions, poorly sorted sandstones and conglomerates in discontinuous beds. The fauna is largely non-marine; some marine levels occur.
The formation rests conformably on the lithological similar (but marine) deposits of the Roda Formation, the boundary being drawn at the colour change from greyish to predominantly brownish hues. It is unconformably overlain by the Collegats conglomerates.

Collegats Conglomerate Formation (Ludian-Oligocene)
The formation is named after the narrow gorge in the Pallaresa valley north of Pobla de Segur (sheet 9, coord. 42°16'-42°17'.4°43').
The Collegats Conglomerate Formation consists of a thick sequence of largely conglomeratic piedmont deposits. Colours vary from light-grey to reddish-brown. Locally marls and coal beds are intercalated near the base (at Sosis, coord. 42°15'.4°40½'). Facies

changes in a southerly direction are shown by a lateral transition into fine-grained sandy and evaporitic deposits.

The unconformity at the base of the formation envelopes a sharp relief near the axial zone of the Pyrenees. The upper boundary, in the area under consideration, is the present topography.

REFERENCES

Alastre, E., Almela, A. & Rios, J. M., 1957. Explicación al mapa geológico de la provincia de Huesca, 1 : 200,000, Madrid. Rev. Inst. geol. minero España, 253 p.

Almela, A. & Rios, J. M., 1947. Explicación al mapa geológico de la provincia de Lérida, 1 : 200,000, Madrid. Rev. Inst. geol. minero España, 193 p.

American Commission on Stratigraphic Nomenclature, 1961. Code of Stratigraphic Nomenclature. Am. Ass. Petr. Geol. Bull., 45, p. 645—665.

Dalloni, M., 1910. Etude géologique des Pyrénées de l'Aragon. Ann. Fac. Sci. Marseille, 19, 444 p.

—, 1930. Etude géologique des Pyrénées Catalanes. Ann. Fac. Sci. Marseille, 26/3, 373 p.

Guérin-Desjardins, B., Latreille, M., 1961. Etude géologique dans les Pyrénées espagnoles entre les rios Segre et Llobregat (Provinces de Lerida et Barcelona). Rév. Inst. Fr. Pétrole, 19/9, p. 922—940.

Hofker, J., 1963. Studies on the Genus Orbitolina (Foraminiferida). Leidse Geol. Med., 29, p. 183—253.

Hottinger, L., 1960. Recherche sur les Alvéolines du Paléocène et de l'Eocène. Schweiz. palaeont. Abh., 75, 76, 243 p.

Misch, P., 1934. Der Bau der Mittleren Südpyrenäen. Abh. Gesellsch. Wissensch. Göttingen, III. Folge, H. 12, p. 1—168.

Peybernès, B., 1968. Précisions stratigraphiques sur le Jurassique terminal et le Crétacé inférieur aux abords de la vallée du Sègre (province de Lerida, Espagne). C. R. somm. Soc. géol. Fr., 1, p. 15—16.

Souquet, P., 1963. Précisions stratigraphiques sur les calcaires d'Auga Salenz (Pyrénées Aragonaises, Espagne). C.R. somm. Soc. géol. Fr., 8, p. 278—280.

—, 1964, Age, situation tectonique et origine des brèches de Campo (Pyrénées Aragonaises, Espagne). C. R. somm. Soc. géol. Fr., 1, p 20—22.

—, 1967. Le Crétacé Supérieur Sud-Pyrénéen en Catalogne, Aragon et Navarre. Thèse de Doctorat d'Etat Sciences Naturelles. Fac. Sci., Toulouse, Avril 1967, 529 p.

Wennekers, J. H. N., 1968. The geology of the Esera Valley and the Lys-Caillauas Massif, sheet 7, Central Pyrenees, Spain, France. Leidse Geol. Med., 41, p. 221—267.