Paradoxes and inaccuracies in the geological maps of scale 1/50 000, which show the Upper Cretaceous of the Southern margin of the Basin of Le Beausset (Provence, France)

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ABSTRACT

On the southern side of the Beausset syncline (southwest Provence), lithostratigraphic and structural propositions are divergent. Since 1978, the available geological map at 1/50 000 has revealed these contradictions. During the recent revision of these maps at 1/10 000 scale and with detailed triasic lithostratigraphy, the authors have proposed a new interpretation of the relationship between the Trias and Santonian in diverse structural units of this area. These facts confirm premature tectonic phases (before Santonian), evoked since 1891 by M. Bertrand in this area (Saint-Jean oratory), where the embryonic structures are taken back in the following phases of the Paleogene. Similarly to the other hills around Toulon (Var), this premature genesis of the provençal folds can be attributed to the diapiric behaviour of the Trias, which seems to be the main engine of these local and initial structures.

Key words : Provence, tectonics, Trias, diapirism, Cretaceous, France

Paradojas e imprecisiones de los mapas geológicos a escala 1:50 000 sobre el Cretácico superior del borde meridional de la cuenva de Beausset (Provenza, Francia)

RESUMEN

En el borde meridional del sinclinal du Beausset (Baja Provenza) las propuestas litoestratigráficas y estructurales son contradictorias. El mapa geológico a escala 1/50 000 disponible desde 1978 revela esas contradiciones. Con ocasión de la reciente revisión de estos mapas a escala 1/10 000 y basándose en la litoestratigrafía detallada del Triásico, los autores proponen una nueva interpretación de las relaciones entre el Triásico y el Santoniense de diversas unidades estructurales de esa zona. Se confirma la existencia de fases tectónicas anteriores pre-santonienses, puestas ya de manifiesto en 1892 por M. Bertrand, cuyas estructuras son reactivadas en fases posteriores durante el Paleógeno. Como en las colinas de los alrededores de Tolon (Var), esta génesis precoz de los pliegues provenzales puede ser atribuida al diapirismo del Triásico, que parece ser el principal causante de estas estructuras locales e iniciales.

Palabras clave: Provenza, tectonica, Triásico, diapirismo, Cretácico, Francia

VERSIÓN ABREVIADA EN CASTELLANO

Introducción y metodología

En Var, en el borde meridional del sinclinal de Beausset (Figs. 1 y 2), las propuestas estratigráficas y estructurales de diversos autores son contradictorias. Estas contradiciones figuran en los mapas geológicos

detallados de Francia a escala 1/50 000 publicados en 1969 (Toulon) y en 1978 (La Ciotat). Consisten principalmente en la interpretación del límite entre el Cretácico (Santoniense) del sinclinal de Beausset y los términos más antiguos (Triásico) de diversas unidades estructurales que le cabalgan hacia el norte (Fig. 4). En efecto, este contacto del Santoniense, considerado como transgresivo (Fig. 3a) en el sector central (vertiente sur de la barra del oratorio Saint Jean), lateralmente aparece como un cabalgamiento, tanto hacia el este como hacia el oeste (Fig. 3b).

La revisión del mapa geológico de la hoja de Toulon a escala 1/50 000 (en curso), cartografiada a escala 1/10 000 y basada en la litoestratigrafía detallada del Triásico (Fig 6) establecida en 2011, ha permitido plantear una nueva hipótesis descartando las contradiciones existentes.

Como M. Bertrand propuso en 1892 en los alrededores del oratorio de Saint Jean, este contradictorio contacto estaría probablemente relacionado con una sucesión de episodios tectónicos que afectan a diferentes niveles del Triásico yesífero y arcilloso. Segun dicho autor, los primeros movimientos habrían dado lugar, de forma puntual, al desarrollo de pequeñas estructuras diapíricas en el Cretácico (Albiense a Campaniense ?) provocando discordancias locales, mientras que los movimientos más recientes (Maastrichtiense a Eoceno), incorporarían esas primeras estructuras al cabalgamiento principal de las colinas del norte de Tolon, donde este tipo de geometrías incipientes y diapíricas ya habian sido observadas en 1967.

Por otro lado, la base del Santoniense, que se ha interpretado como transgresiva o tectónica, está sistemáticamente jalonada por un conglomerado de fragmentos angulosos o redondeados (Fig. 7) de diversa naturaleza, principalmente triásicos, a veces jurásicos y excepcionalmente cretácicos. Solo la matriz de este conglomerado contiene restos de organismos cretácicos (equinodermos, rudistas, etc.). Tal heterogeneidad litológica está de acuerdo con la presencia próxima de un relieve incipiente, en proceso de formación, en el que algunos afloramientos de rocas anteriores al Cretácico Superior habrían sufrido procesos erosivos.

La revisión actualmente en curso, basada en una litoestratigrafía actualizada (Fig. 6), ha permitido reforzar la hipótesis tectónica determinando un conjunto de unidades estructurales, constituidas esencialmente por el Muschelkalk, generadas en la base de la unidad de Bandol y transportadas hacia el norte sobre el sinclinal de Beausset.

Separados por un nivel arcilloso y yesífero, los dos principales niveles competentes del Muschelkalk calcáreo inferior y superior, son unidades en las que los pliegues disarmónicos constituyen una característica del Triásico Medio y Superior.

Este estilo es comparable al del Triásico descrito en las hojas a escala 1/50 000 de Brignoles, Cuers y Toulon, donde la sucesión estratigráfica es similar y condiciona el inicio y el desarrollo de la halocinesis. Las fases sucesivas alcanzan su paroxismo despues del Santoniense, siendo estas las responsables de las estructuras actualmente observables.

No hay por tanto discordancia en la barra del oratorio de Saint Jean, pero sí una acumulación de escamas tectónicas del Muschelkalk y del Santoniense, transportadas por y bajo la unidad de Bandol (Fig. 9). La interpretación estructural de 1985 y 1987 sobre la unidad parautóctona cretácica (Fig. 4) y en consecuencia, la barra del oratorio Saint Jean, están también por reconsiderar. En efecto, como el trazado sinuoso de su límite septentrional coincide con el de las curvas de nivel, este contacto anormal no puede ser interpretado como vertical (Fig. 5), es decir, relacionado con una etapa distensiva. Presenta una vergencia sur, más acorde con la de la base de la unidad de Bandol cabalgante hacia el norte, más inclinada (Figs. 8 y 9) y compresiva.

Discusión y conclusiones

Estas nuevas observaciones precisan el modelo de emplazamiento de las estructuras cabalgantes provenzales, que en la region de Tolón comienzan en el Albiense para finalizar en el Rupeliense. La presencia de multiples niveles de despegue en el Triásico y este tipo de deformación, caracterizan el estilo provenzal, donde las estructuras incipientes emergen desde el Cenomaniense y son rápidamente expuestas a la erosión antes de iniciarse su emplazamiento. Cualquiera que sea la causa de este, es la compartimentación de los terrenos post-triásicos la que genera la complejidad de los cabalgamientos provenzales.

Introduction

The detailed geological maps of scale 1/50 000, which commenced in 1924, made it possible to integrate new observations that 19th century geologists had introduced, including structural and lithostratigraphic concepts which could not previously be represented precisely. Thanks to the larger scale, these new concepts now had the ideal medium to allow the discussion and refinement of structural models. This has led to a better understanding of the sub-surface geology in the domains of mining, water supply and land-use

planning. The first maps to be developed were the sheets for Marseille and Toulon, which led to a wide range of improvements and the emergence of new concepts, such as the gravity-slide tectonics of Léon Lutaud (1935), the overthrust sheets of lower Provence (1925-1930) of Émile Haug, then the thrust sheet of the lower Provence sediments, by Ion Argyiadis (2000).

The second edition of the Toulon map was published in 1969. Its revision was begun in 2008, following the Marseille map, and the revised draft was sent to the National Committee for Geological Maps in the summer of 2013. Each of these two maps now incorporates part of the "La Ciotat" sheet (Fig. 1), published in 1978. This revision was motivated by the antiquity of the original maps, and by the availability of numerous research studies carried out by the Universities of Marseille and of Paris since the original publication.

Taking into account that in 2011 the programme for updating the Geological Map was replaced by the Geological Reference System for France (RGF), the work involved in revising the Toulon sheet has come mainly from volunteers, and from compilations of studies published since 1969. The new map will be integrated by the RGF, and will be distributed only in digital form. Its announcement will be made in a special number of the BRGM journal: Geology of France. This paper is only a part of the final version, focussed on the relationship between the Trias and the more recent formations. It was presented on the occasion of a geological colloquium on the Cretaceous which took place in November 2013 at the Maison du Terroir et du Patrimoine of La Cadière d'Azur (Var, France).

Since 1969, the mismatches between the maps of Toulon and La Ciotat have given rise to several research studies which clarify the structural and sedimentological evolution of this region. The relationship of the upper Cretaceous of Le Beausset (Fig. 2)
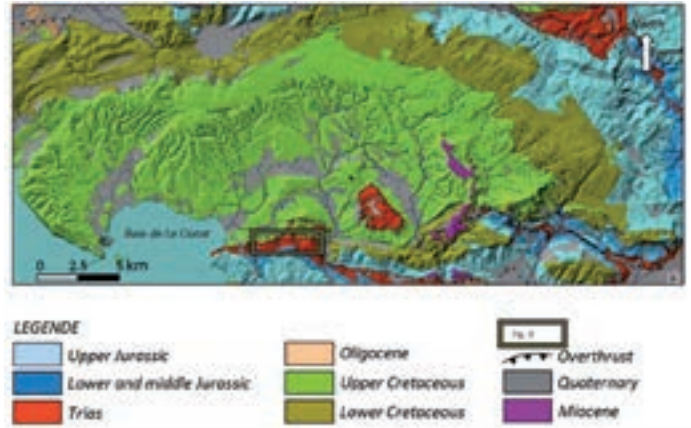

Figure 2. Simplified geological map of the basin of Le Beausset (Var - Bouches du Rhône, France).
Figura 2. *Mapa geológico simplificado de la Cuenca de Beausset (Var-Bouches du Rodáno, Francia).*

with the Trias, shows the evolution of our knowledge and the unresolved questions:

Following the observations of Marcel Bertrand (1891), Jean Philip (1967) described, on the southern slope of the crest of the Saint-Jean oratory, the transgressive discordance of the Santonian on the Trias (Fig. 3a).

This site exhibits the precocious mobility of the southern slope of a syncline during its formation. A few kilometres further east, near Saint-Anne d'Evenos in the valley of Cimai and on both sides of the ridge of la Jaume (Val d'Aren), the results of this instability have been similarly observed in the sediments from

Figure 3. a: The "transgressive" contact between Santonian CsR and Trias t3-6. b: The tectonic contact between Santonian CsR and Trias t3-6.
Figura 3. *a: El contacto "transgresivo" Santoniense C_sR/Triásico t3-6. b: El contacto tectónico Santoniense C5R/Triásico t3-6.*

Figure 1. Geological maps in the process of being revised.
Figura 1. *Mapas geológicos en fase de revisión.*

the Aptian to the Turonian (J. Philip and J.P. Masse 1969, J. Philip *et al.,* 1985 and 1987). However, in the communes of Saint-Cyr-sur-Mer and the Cadiere d'Azur, from Rampale to the hill of the Aoube and including the oratory of Saint-Jean, the Santonian with a conglomerate at its base can be observed in various localities, apparently transgressive over the Triassic.

But from the south of Baumelles to the north of the Aoube and passing through Allons, the 1978 map like that of 1987 (J. Philip, L. Machhour and J. P. Masse, Fig. 1) shows in the continuation of the transgressive contact, a tectonic contact between Trias and Santonian (Fig. 3b), even though the conglomeratic facies of the latter lies almost vertically against, and even beneath, the Triassic terrain of the Bandol unit.

Furthermore, the limits and the stratigraphic identities of the Triassic units are imprecise with regard to the information available in 1987, such as the publication by J.P. Caron (1967a and b). The Keuper is represented at the expense of the Muschelkalk, notably basaltic (Fig. 7 and following pages). In addition, the levels of tectonic displacement are ignored, although they were clearly shown on the Toulon sheet (1969). Finally, in the 1978 map (Fig. 4), the Santonian and the Trias of the oratory ridge is described as a parautochthonous unit at the front of the overthrust unit of Bandol. But in the 1985 studies (J. Philip *et al.,* 1985) based on the drillings of 1965 between Rampale and the Baumelles, this unit is interpreted as a horst (Fig. 5), despite its continuity with the overthrust units which prolong it to both east and west, and in spite of the of the sinuous nature of the so-called fault indicating a slope toward the south and not vertical or towards the north!

Identified by M. Bertrand (1891), this paradox of a Trias/Santonian contact, interpreted in one case as tectonic, and in another as sedimentary, could only lead to endless discussions in the absence of new

mapping. In the context of the revision of the Toulon-La Ciotat sheets, the updating of the local map has been carried out by J.P. Caron, whose studies of the Trias in Provence (Toulon, Brignoles, South of Barjols) over the last 48 years have not been applied to this sector. In fact, even though they are mentioned in the notice accompanying the La Ciotat sheet published in 1978, they have not been integrated into this map. Figure 6 is a summary of the lithostratigraphy of western Provence, which is described in detail in the next section (2).

Lithology and stratigraphy of the Triassic Series (Fig. 6)

Permian and Lower Trias: t1-2

The south-east basin is one of the three large Mesozoic basins in France. It is bounded on the west, alongside the Massif Central, by the SW-NE Cevennes fault, and on the north by the Jura basin and the Swiss Alps. To the east and south-east, the Alpine and Pyrenean deformations make it difficult to study this passage into the Alpine sedimentary domain.

These two periods are well represented from Sanary-sur-Mer, along the coast as far as Hyères, then toward the north-east, along the "Permian depression", around the massif of the Maures-Esterel-Tanneron and the Barrot dome and then the massif of Argentera-Mercantour.

The most western sector where the lower Trias outcrops, to the west of Sanary, is the point of Portissol. The cliff section (Caron J.P., 1965c; Glinzboekel and Durand, 1984) shows the following sequence: (i) One basal conglomerate level which contains layers of pebbles of wind-eroded vein quartz ("dreikanters") and siliceous sandstone. (ii) Above this, an alternation
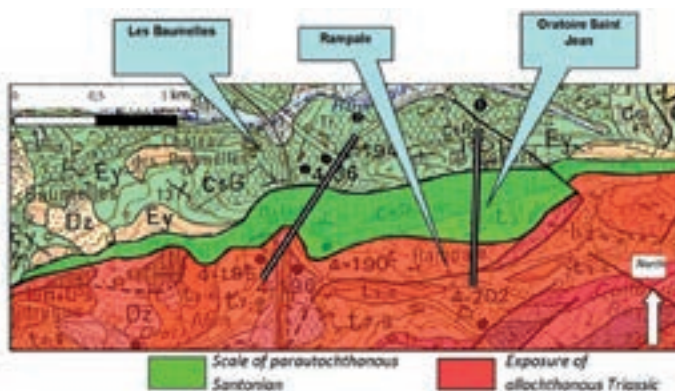

Figure 4. Main units in the 1978 map.
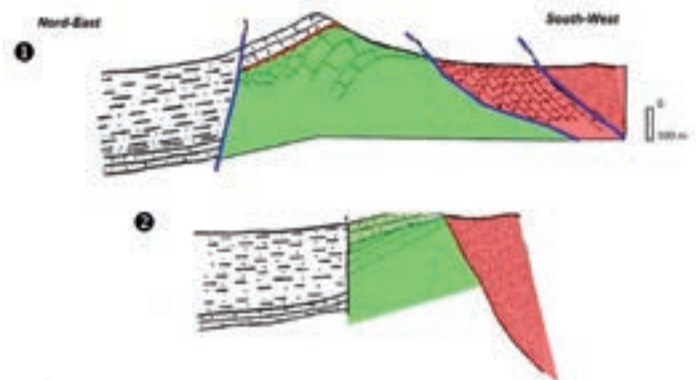*Figura 4. Unidades principales en el mapa de 1978.*

Figure 5. Cross sections in Figure 19 from J. Philip *et al.* 1985 (position and legend in Fig. 4).
Figura 5. Cortes geológicos de 1985 en Fig. 19 de J. Philip et al. *1985.*

(60 to 80 m) of sandstone (coarse to micaceous clay sandstone), then psammites, argillaceous red sandstone (some with cross-bedded stratification), and towards the summit, pale dolomitic sandstone, with ripple marks. These formations of Buntsandstein indicate a continental fluviatile environment, with arid climate, and are probably of Smithian age.

From the structural point of view, the lower Trias and the Permian represent the solid "basement" of older formations, except in the Toulon region, where they are overthrust by the metamorphic, Variscan sequence, pushed towards the N-NE (M. Bertrand and Ph. Zurcher, 1891; J.P. Destombes, 1951).

Middle Trias: t3

In this sequence, limestone and dolomitic formations, more particularly known for their fossiliferous layers, attracted the attention of geologists and palaeontologists, and triggered the first comparisons with the "Germanic" middle Trias. But it is especially from the tectonic point of view that their role and importance are most evident. Intensely folded, they are responsible for the overthrusting of the Mesozoic cover-rocks of Provence, and their consequences in the building of the main mountain ridges in Provence. Three subdivisions can be distinguished:

Lower Muschelkalk: t3a-b

t 3a – In the bay of Portissol (west of Sanary), the cliffs show a continuous section starting with the top of the Buntsandstein, a bed of thin sandstone slabs (about 5 m) with cubic pseudomorphs of halite, and red clay, yellow and plastic at the top, signalling the first marine incursion. This bed provides a reference horizon, which continues towards the north and west as far as the arc of Nice (J. P. Caron and L. Roux, 1966), but with variable thicknesses, especially for the clays and marls. Above this appear evaporitic beds, of gypsum and/or anhydrite (0 to ~ 30 m), often as lenses of variable thickness, sometimes absent and/or laminated. They outcrop rarely, but can give rise to subsidence and/or slippages. Some of them have been exploited by artisans, in underground quarries, some of which are no longer visible. These evaporites, associated with clays or marls, behave in a ductile or plastic manner, associated with disharmonic folds. They form the first plane of slippage for the overlying sedimentary rocks of Provence (φ 1, between t3a and t3b in Fig. 6).

t 3b – 3 parts are distinguished:

At the base: dolomitic limestone, dolomites, or cargneules (~ 5 to ~ 10 m). If the contact with t3a is affected tectonically, these rocks can be brecciated or changed to cargneules. In the middle: smoke-grey limestone, in massive banks (~ 50 m), with a few intercalations of small beds which are well-stratified and affected by bioturbations of the type Rhyzocorallium. No classically described macrofauna are present, but a few centimetre-thick beds of coarse limestone can be observed. At the top: dolomitic limestone, dolomites, and/or cargneules (~ 5 to ~ 10 m), a formation comparable to the one at the base, makes up the final part of the middle Muschelkalk. The cliff at the fort of Sainte Marguerite (south-east of Toulon - Caron J.P., 1968) represents a type section whose normal position is confirmed by the presence,
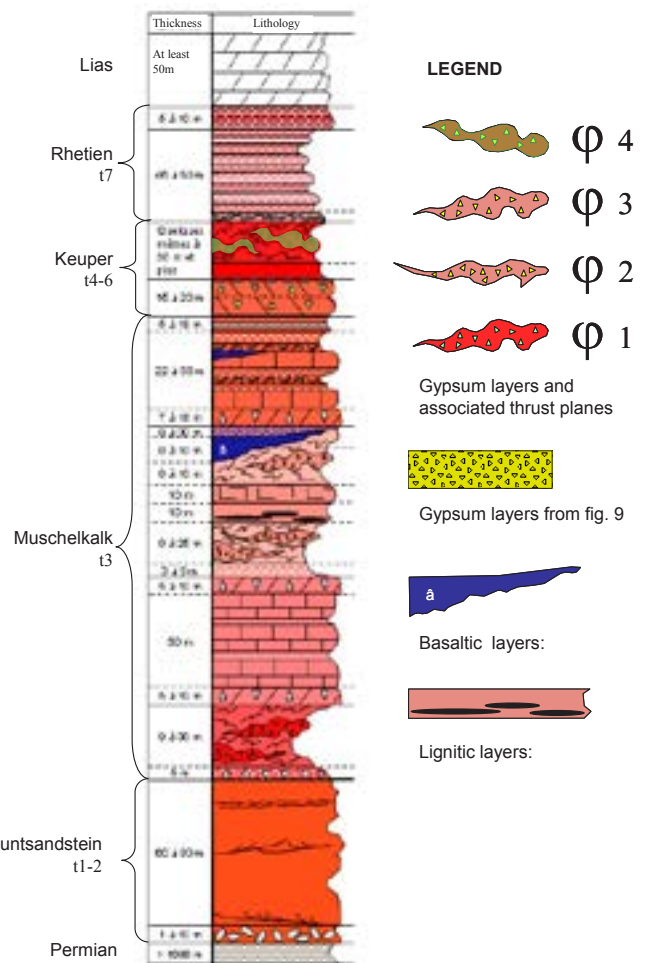

Figure 6. Litho-stratigraphic sequence of the Trias in Provence (Caron J.P., Durand M. *et al.*, 2011, modified - As this varies greatly for sedimentological and tectonic reasons, the thicknesses shown are average values).
Figura 6. *Columna litoestratigráfica del Triásico provenzal. Caron J.P., Durand, M.* et al. *2011 modificada*

at the top, of a bed a few metres thick of argillaceous limestone in small bands, containing drop-stones. This group of competently bedded rocks forms the first level which is deformed tectonically in a coherent way, and whose structures can be reconstituted with reasonable accuracy.

Middle Muschelkalk: t3c

The detailed stratigraphy of the middle Muschelkalk has been established by studying the sections in several mineral mining sites in the Toulon region. The youngest calcareous and dolomitic levels of the lower Muschelkalk pass upward into a finely-bedded argillaceous layer (3 to 5 m), sometimes deformed at the base of the middle Muschelkalk. Above this, there are essentially three types of rocks:

As in t3a, there are layers of gypsum and anhydrite (0 to ~ 25 m) which outcrop rarely, often in lenses of irregular thickness, of several tens of metres. They are sometimes absent, or laminated and associated with marls and/or clays. These accumulations can also give rise to sink holes and/or slippages, some of which have been exploited by artisans, in underground quarries, partly inaccessible today. These rocks are ductile and plastic, and behave similarly to those in t3a (slip surface φ1 in Fig. 6). They make up an important part of t3c, and are the site of the second surface of slippage in the sedimentary cover φ2 (see Fig. 6). In some sectors, they include pockets of marls (~ 10 m), with intercalated lignites (a few decimetres), some of which have been exploited (east of Ollioules), and/or a bed of smoke-grey limestone and pale grey dolomitic limestone, (~ 10 m), with thickness and facies different from those of the lower Muschelkalk. Beds of gypsum and anhydrite may also occur above. Thus the slippage plane 2 in Figure 6 may split into φ2a and φ2b in Figure 9c. Towards the top, the middle Muschelkalk contains intercalations of volcanic rocks and volcanic sediments, found at Saint-Cy-sur-Mer and Rampale (Caron J.-P, 1969a) then at Méounes (Caron J.-P., 1973), at Tourves and Barjols, etc. (Caron J.-P., 1969b and c, 1979), at southeast of Oratoire Saint-Jean (Fig. 8) and more eastern.

Upper Muschelkalk: t3d

The calcareo-dolomitic type facies of the upper Muschelkalk presents a remarkable lateral continuity of the principal beds, without notable variation of facies, and with relatively moderate variations in thickness. Some horizons are characterised by microfauna and microflora not described in Provence. These form marker horizons of wide lateral extent. The study of sedimentation patterns and polarity indicators has shown that some units were displaced and/or overturned, whilst others have been positioned vertically and, finally, some remain in their normal orientation (Caron J.-P., 1965a and b). Four lithological formations of regional extent have been defined (Caron J.-P., 1965a and b; Caron J.-P. and Gauthier A., 1968):

Formation I. Often brecciated, these are dolomitic limestone and dolomites of pale grey to pale yellow colour, diaclastic and cargneulised at their contact with the slippage-plane affecting the middle Muschelkalk (slippage plane φ 2 in Fig. 6).

Formation II. Marly (or argillaceous) horizons alternate with beds of fossiliferous, compact or nodular limestone (~ 22 to ~ 25 m). The lower limit corresponds to the top of the highest bed of dolomitic limestone of formation I. The following layers contain the classical and caracteristic fossils (terebratula, crinoids, dasycladacea and others). The passage to formation III is continuous.

Formation III. Of variable thickness (~ 5,30 m to 17,80 m), this formation has the following characteristics: (i) Alternation, in the lower part, of smoke-grey biomicrites and limonitised biosparites showing evidences of polarity. (ii) Presence of "soft" pebbles of smoke-grey limestone (10 to 15 cm), of intra-formational microconglomerates, and channels 15 to 20 cm deep. (iii) The facies of smoke-grey limestone with abundant worm traces is similar to that of the lower calcareous Muschelkalk.

Keuper: t4-6

No continuous section can be observed because of the presence of the forth level of overthrusting (φ 4 in Fig. 6). It is still possible to distinguish:

Lower Keuper: t4 or Formation IV

In continuity with the last levels of smoke-grey limestone at the top of formation III, formation IV (~ 15 to ~ 20 m) shows close similarities with formation I: dolomitic limestone and dolomites of pale yellow to pale grey colour, but with more clearly marked stratification. At the upper level of formation IV, there are some siliceous concretions. All these beds are difficult to differentiate, and have been attributed to the Lettenkohle (t4).

Upper Keuper: t5-6

This stage can equally give rise to subsidence or slippages. Associated with evaporitic layers, there are marls or red clays, sometimes containing quartz bipyramids. Where they outcrop, these red clays show abnormal contacts: on the south slope of the Sainte-Baume and the upper layers of the overturned sequence of its high chain, and along the "hinge" between the normal sequence of Le Beausset. Locally, beds of dolomite may be intercalated. These rocks, ductile and plastic, behave in a disharmonic way identical to the rocks of t3a and t3c. They are the site of the level of lateral slippage, φ4 of Figure 6. The lack of distinction between these different levels had generated numerous and incomplete or ambiguous structural interpretations.

The presence of 2 sequences of calcareous and calcareo-dolomitic rocks, which are compact and competent, alternating with 3 layers of plastic, ductile rocks, make up a finely multilayered roof to the basement of the lower Permo-Triassic, and beneath the Rhetian. The layers of evaporites made possible the early recognition of the deformations within the middle and upper Trias, and their effects [repercussion] on the overthrusting of the post-Keuper sedimentary cover. They play a vital role in the salt deposits in Provence, already identified in the Trias of Tourves, Barjols and the surrounding area (J.P. Caron 1969c; Rouire J. *et al.* 1979). The resulting structures, clearly distinguishable on the maps of Toulon, Cuers and particularly of Brignoles and others, are the result of diapiric activity which was a particular stage in the repeated tectonic activity which gave the overlying formations of Provence their distinct style.

Rhetian: t7a-b

In such complex structures, when outcrops allow observations, it is possible to distinguish:

Lower Rhetian (t7a): over a thickness of 45 to 50 m, the basal sequence is composed of a fossiliferous microconglomerate with *Avicula contorta* (~ 10 cm), followed by an alternation of green marls and beds of ochre-yellow limestone and bioturbations.

Upper Rhetian (t7b): for 5 to 10 m, a bed of beige, fine-grained limestone, with conchoidal fracture, followed by limestone and dolomitic limestone of the Hettangian.

New observations and consequences

When one observes the contact between Santonian and Trias, in the segments called transgressive or tectonic, the conglomerate facies of the Santonian persists. It is always clearly observable to the north of the hills of Allons and the Aoube (Figs. 7a to 7c).

These paradoxical contacts favour the probable advance of the Santonian over a pre-existing relief due to tectonic activity, allowing the Trias to outcrop earlier than expected. Taking into account the tangential displacements which affected the Mesozoic sequence during Paleocene to Bartonian and the complexity of the Triassic structures, not integrated in previous studies of oratoire Saint-Jean area, the contacts observed in this sector of the Beausset basin between the Trias and the Cretaceous, can only be tectonic. It follows that these structures obviously developed to the south of their present outcrops. The absence of tectonic facies (breccia, mylonite,
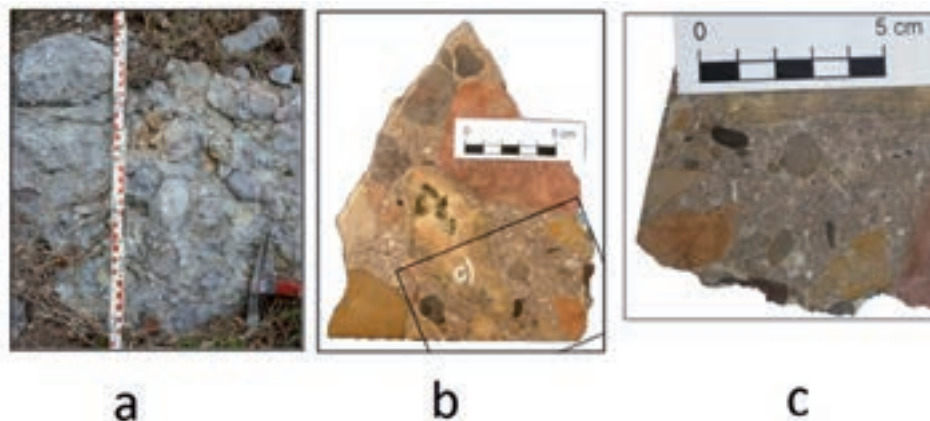

Figure 7. The Aoube: basal conglomerate of Santonian against sub-vertical Muschelkalk.
a) Outcrop at the top of Santonian (under overlapping Trias). b) Heterometry and heterogenity of elements. c) Matrix details
*Figura 7. Aoube: conglomerado de base del Santoniense en contacto subvertical con el Muschelkalk.
a) Afloramiento; b) Heterometría y heterogeneidad de sus elementos; c) Detalle de la matriz.*

gypsum injections, etc.) at the base of the Trias in contact with the Santonian, is not sufficient to interpret this contact as a simple transgressive contact. Moreover, an undoubtedly tectonic contact along the Pointe Grenier (Saint-Cyr-sur-Mer), where the Muschelkalk overthrusts the argillaceous Santonian, does not show any of these tectonic facies.

Furthermore, from Allons to the Aoube, the varied sizes of the coarser elements of the Santonian conglomerate (Fig. 7) and the diversity of their age (Jurassic to lower Cretaceous), may be the result of a salt-induced tectonic activity (halocinesis), at least as early as the Albian, which shows the first instability of the relief further to the south (Évenos section in J. Philip and J.P. Masse, 1969). The lithologic and stratigraphic heterogeneity of the elements of this conglomerate, contradicts a regular arrival of uniform-sized terrigenous debris in the upper Cretaceous basin coming from a distant southern continent and made up of Palaeozoic rocks. Such homogeneous deposits are visible in the vicinity of oratoire Saint-Jean. With this perspective, and during

the pre-Oligocene tectonic phase, the overthrusting unit of Bandol would advance obliquely over the local relief, which had already appeared in the southern neighbourhood of the current outcrops of Santonian conglomerate. The Trias structures, underlying the thrust unit of Bandol (J.P. Caron and P. Laville 2013) show evidence of this (Figs. 8 and 9). Between Rampale and Allons, and from west to east, 3 structural units are distinguished (J.P. Caron and P. Laville, 2013) in the body of the Trias encountered between the Bandol and the Beausset units. The sections in Figure 9 illustrate their relationship.

Conclusions

In this succession, the pre-Santonian salt movements may be the cause of the local discordances of the Santonian over the Muschelkalk, or over other levels of the Cretaceous. However, Cenozoic tectonic episodes could equally well contribute to such a superposition, even more complex if the first displacement
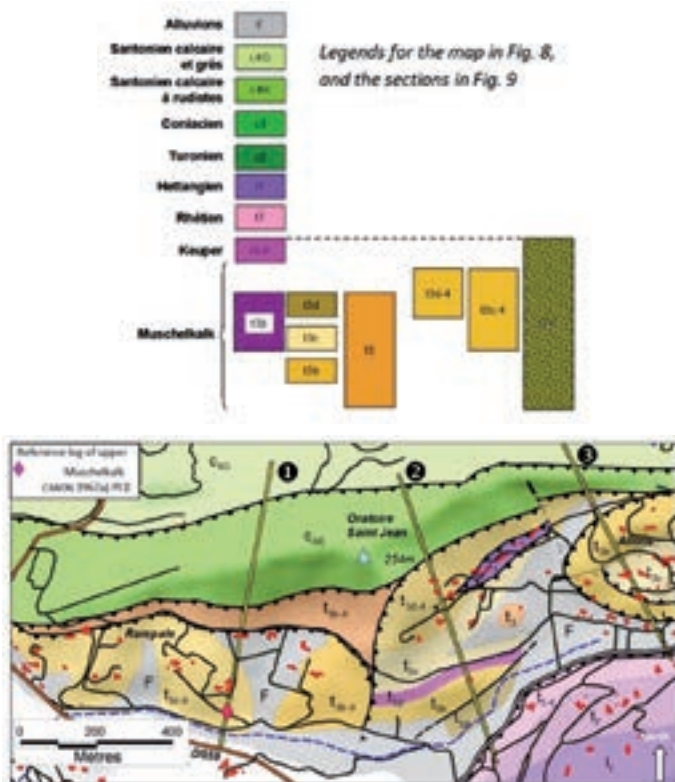

Figure 8. Detailed geological map from Rampale to Allons, Caron J.P., Laville P. 2013. (Legends for the map *in* Fig. 8, and the sections *in* Fig. 9).
Figura 8. Mapa geológico detallado entre Rampale y Allons, Carons J.P., La Ville P. 2013 (Leyenda del mapa en la Figura 8 y de las secciones en la Figura 9).
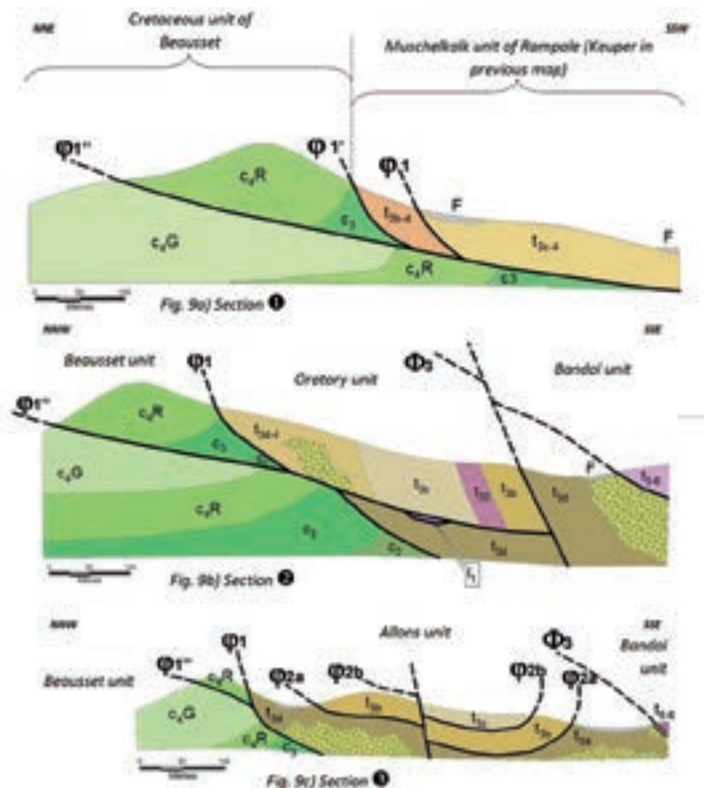
Figure 9. Geological sections (see positions *in* Figure 8). Overthrust φ legend see Figure 6. (Φ_3 corresponds to the contact of the major allocthonous unit upon its frontal scales). a) Section u b) Section v c) Section w.
Figura 9. Cortes geológicos (situación en Figura 8). a. Corte 1 ; b. Corte 2 ; c. Corte 3.

has already taken place. The case of the rudist bed of the Saint-Jean oratory seems to clearly illustrate this multi-phase process. We strongly recommend new studies of the southern flank of the Beausset syncline, taking into account these recent issues which are in the process of being updated.

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