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Tectonics

The AIG10 drilling project (Aigion, Greece): interpretation of the litho-log in the context of regional geology and tectonics

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Abstract

In the frame of the EU Project Corinth Rift Laboratory (CRL), the AIG10 borehole was successfully drilled from July until September 2002 through the Aigion normal fault in the harbour of Aigion, northern Peloponnesus, Greece. The scientific objective focuses on the investigation of fault mechanics and the relationship with fluid flow and geochemistry, fluid pressure, stress- and strain fields and earthquakes. Recognition of stratification encountered in the AIG10 borehole is based on an online analysis of well cuttings (0–708.8 m and 787.4–1001 m), core descriptions (708.8–787.4 m), monitoring of drilling parameters, as well as a preliminary geophysical well-log interpretation (0–1001 m). Geologically, the area is part of the Olonos–Pindos tectonic nappe, which is overthrusted on the Tripolitza unit during the Alpine orogeny. The litho-log of the AIG10 borehole comprises at first syn-rift deposits (graben fill). At 496 m, the Olonos–Pindos tectonic unit was encountered, however, not as expected in the platy limestones, but in the Olonos–Pindos radiolarite. The borehole has crossed at least one thrust-fault zone and a major normal fault zone at 760 m. This normal fault zone separates well-fractured platy, micritic limestone in the hangingwall from highly fractured radiolarite in the footwall, both of the Olonos–Pindos tectonic unit. The observed succession of multiple imbrication is an indicator of Alpine tectonic activity, whereas normal faulting is of the Miocene–Quaternary extension of the Gulf of Corinth, confirming our expectations gained from geologic-tectonic fieldwork. ***To cite this article: D. Rettenmaier et al., C. R. Geoscience 336 (2004).***

Résumé

Corrélation des analyses lithologiques et structurales du forage AIG10 avec l`environnement régional tectono–géologique. Le forage AIG10 a été réalisé avec succès de juillet à septembre 2002 à travers la faille d'Aigion dans le port d'Aigion (Nord-Péloponnèse, Grèce). Les travaux ont été entrepris dans le cadre du projet européen 'Corinth Rift Laboratory (CRL) – Gulf of Corinth'. La caractérisation stratigraphique a été effectuée sur la base des débris de forage, des carottes et des paramètres de forage ainsi qu'à partir des diagraphies électriques. Après une courte présentation du cadre tectonique régional et des conditions géologiques dans l'environnement du forage AIG10, la stratigraphie et les relations structurales rencontrées dans

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le forage sont décrites en détail. Les dépôts syn-rift traversés jusqu'à 496 m de profondeur sont composés, d'après Lemeille et al. (ce numéro) d'alternances de sédiments détritiques plus ou moins grossiers (conglomérats, graviers, sables, argiles et silts carbonatés), qui peuvent être regroupés en au moins huit unités. Après une séquence argileuse rougeâtre, la partie supérieure de la nappe mésozoïque du Pinde–Olonos a été atteinte avec des radiolarites. En raison de la variabilité lithologique entre calcaires, marnes et radiolarites de 506 à 696 m, on peut supposer l'existence de plusieurs chevauchements. Les premières carottes de forage, correspondant à l'intervalle 708–744,8 m, montrent la structure feuilletée et fracturée typique des calcaires en plaquettes du Pinde–Olonos. La zone centrale de brèches de la faille d'Aigion a été rencontrée à 756 m de profondeur, sur au moins 4 m d'épaisseur. De 774 à 787,4 m, les carottes sont constituées de calcaires avec des caractéristiques différentes de celles des calcaires en plaquettes supérieurs et appartiennent probablement à la nappe inférieure de Tripolitza, dans laquelle serait développé un karst. L'analyse des débris de forage entre 787,4 et 1001 m (fin du forage) n'a pas montré de variations lithologiques notables. ***Pour citer cet article : D. Rettenmaier et al., C. R. Geoscience 336 (2004).***

Keywords: Aigion; AIG10; Corinth; Greece; fault zone; ICDP; litho-log; Olonos Pindos; tectonic; thrust nappe

Mots clés : Aigion ; AIG10 ; Corinthe ; Grèce ; zone de faille ; ICDP ; log lithologique ; Olonos Pindos ; tectonique ; nappe de charriage

Version française abrégée

Le forage AIG10 a été réalisé avec succès de juillet à septembre 2002 à travers la faille d'Aigion dans le port d'Aigion (Nord-Péloponnèse, Grèce). Les travaux ont été entrepris dans le cadre du projet européen *Corinth Rift Laboratory (CRL) – Gulf of Corinth*. L'objectif scientifique a porté sur l'investigation des relations entre la cinématique des failles, la géochimie et les transferts de fluides dans et autour des zones de faille, la pression des fluides, les champs de contraintes et de déformation, ainsi que les séismes. La caractérisation stratigraphique du forage AIG10 a été effectuée sur la base de l'analyse en continu des débris de forage (de 0 à 708,8 m et de 787,4 à 1001 m), de la description des carottes de forage (de 708,8 à 787,4 m), du contrôle des paramètres de forage, ainsi que de l'interprétation préliminaire des diagraphies électriques (0 à 1001 m).

Du point de vue géologique et tectonique, le Nord du Péloponnèse est caractérisé par des nappes de charriage qui peuvent être séparées en plusieurs unités tectoniques. La région d'Aigion et le forage AIG10 sont situés dans l'unité tectonique du Pinde–Olonos (Fig. 1(a) et (c)), qui comprend en succession normale, de bas en haut, des radiolarites du Jurassique au Crétacé inférieur, des calcaires en plaquettes du Crétacé au Tertiaire et des flyschs du Tertiaire, représenté par des grès. En raison de l'activité tectonique, la structure géologique est caractérisée par des chevauchements ainsi que par des failles normales synthétiques et antithétiques. Les chevauchements, qui plongent surtout vers le sud-est et sont connectés à des plis à vergence nord-ouest, appartiennent à la tectonique alpine de charriage. Les failles normales, qui plongent vers le nord (synthétiques) et vers le sud (antithétiques), appartiennent au processus d'ouverture du golfe de Corinthe, d'âge Pliocène à Actuel. La nappe du Pinde–Olonos est déformée en imbrications multiples et chevauche la nappe allochtone de Tripolitza. Les imbrications multiples et les structures en duplex sont responsables de la complexité de reconstitution des séquences stratigraphiques et de la variabilité lithologique. La maîtrise de la dynamique et de l'architecture tectonique sont les clés nécessaires pour comprendre la succession rencontrée dans le forage AIG10.

Les formations syn-rift traversées par le forage AIG10 (Fig. 3) comprennent au moins huit unités d'après Lemeille et al. (ce numéro). Après 3,5 m de sol argileux, des argiles de l'Holocène et du Pléistocène supérieur, ainsi que des marnes et des sédiments fluviatiles du Meganitas, ont été rencontrés dans la partie supérieure du forage AIG10. Cette séquence de 3,5 à 125 m de profondeur est caractérisée par des graviers sableux fins et moyens, intercalés avec des couches argileuses et limoneuses. Des conglomérats rigides, en alternance avec des couches de sables et d'argiles ainsi que des intercalations marines, ont été traversés dans le forage entre 127 et 388 m. Les conglomérats sont composés de matériaux détritiques transportés par l'eau et bien arrondis provenant des calcaires, marnes et grès, ainsi que d'éléments moins bien arrondis provenant des radiolarites et des cherts du Pinde–Olonos.

Cette unité repose sur un ensemble de transition marin argilo–sableux. La partie basale du forage, jusqu'à 496 m, est composée d'argiles marines gris foncé, carbonatées et plastiques, moins limoneuses, contenant des fossiles et du nannoplancton d'âge Pléistocène. Après une séquence argileuse rougeâtre, la partie supérieure de la nappe mésozoïque du Pinde–Olonos a été atteinte à 496 m dans des radiolarites. À une profondeur d'environ 696–698 m, un chevauchement a été identifié, permettant un contact anormal des radiolarites jurassiques sur les calcaires crétacés. En raison de la lithologie hétérogène et changeante entre calcaires, marnes et radiolarites entre 506 et 696 m, on peut supposer l'existence de plusieurs chevauchements supplémentaires, ainsi qu'une certaine influence du plissement sur la géométrie d'ensemble.

La série suivante de calcaires crétacés commence à 698 m de profondeur et est caractérisée par des débris de forage constitués de calcaires et de marnes brun clair et gris-vert. Les premières carottes de forage correspondent à l'intervalle 708–744,8 m et montrent la structure feuilletée et fracturée typique des calcaires en plaquettes du Pinde–Olonos. Une séquence présentant un caractère cataclastique évident a été rencontrée à une profondeur d'environ 745 m. Les calcaires en plaquettes du Pinde–Olonos sont intensément bréchifiés et plusieurs bandes cataclastiques ont été rencontrées au-dessous de 745 m. Ces bandes de cisaillement et ces zones cataclastiques forment le début d'une faille normale majeure, qui doit être la faille d'Aigion. La zone centrale de la brèche de faille a été rencontrée à 756 m de profondeur, avec une épaisseur minimale de 4 m. La zone de faille sépare le calcaire en plaquettes bien fracturé du compartiment toit et les radiolarites fortement fracturées du compartiment mur (Fig. 3).

Après la traversée de la zone de faille, une augmentation en pression d'eau souterraine de 0,5 à 1,0 MPa a été enregistrée. Les radiolarites fracturées et la haute pression de l'eau ont entraîné une faible récupération des carottes. Les diagraphies électriques soulignent le contact avec les calcaires à 774 m de profondeur. Les carottes de 774 à 787,4 m (fin du carottage) ont été prélevées dans des calcaires dont les caractéristiques sont différentes de celles des calcaires en plaquettes de la partie supérieure et qui appartiennent probablement à la nappe inférieure de Tripolitza. Les dernières carottes et la haute pression de l'eau suggèrent des conditions d'écoulement souterrain karstique. En raison du débit artésien et de la forte pression d'eau, le carottage à été arrêté à 787,4 m de profondeur et le forage s'est poursuivi en mode *rotary*. L'analyse des débris de forage n'a pas montré de variations lithologiques importantes jusqu'à la profondeur finale de 1001 m.

1. Introduction

In the spring 2001, we started working on an ICDP/DFG (German Research Foundation) funded project exploring the thermo-hydraulic conditions in the area of Aigion and its hinterland (Fig. 1). This project comprises geologic mapping, hydraulic experiments, geophysical logging in boreholes and modelling of a regional 2-D cross section and is aimed to interact with the CRL project cluster CORSEIS, DGLAB, 3F and AEGIS. As part of this work, we were able to support geologically the drilling of the deep AIG10 borehole in the summer 2002 under the responsibility of the ICDP Operational Support Group of GFZ Potsdam. Here, we report our geological observations and interpret the results in the context of regional geology and tectonics. A cross section with the AIG10 borehole located on can be found in Giurgea et al., this issue. The 1001 m deep borehole was drilled in the frame of the EU project DGLAB co-funded by *ICDP*. Special thanks is given to Lemeille et al. [11] for accompanying the monitoring and description of the cuttings of the Corinth graben fill and to the team of Moretti et al. [14], which was responsible for the cores of AIG10, recovered between 708.8 and 787.4 m.

2. Regional tectonics and stratigraphy

2.1. The Olonos–Pindos Unit in the region of Aigion

As a result of the Alpine orogeny, the main part of Greece, and especially the Peloponnesus, can be separated into several tectonic units, belonging to the Dinarides–Hellenides (Fig. 1). The Hellenides represent a supracrustal formation of mainly Mesozoic and Cenozoic sediments. In the Peloponnesus, several thrust sheets are developed reflecting five tectonic

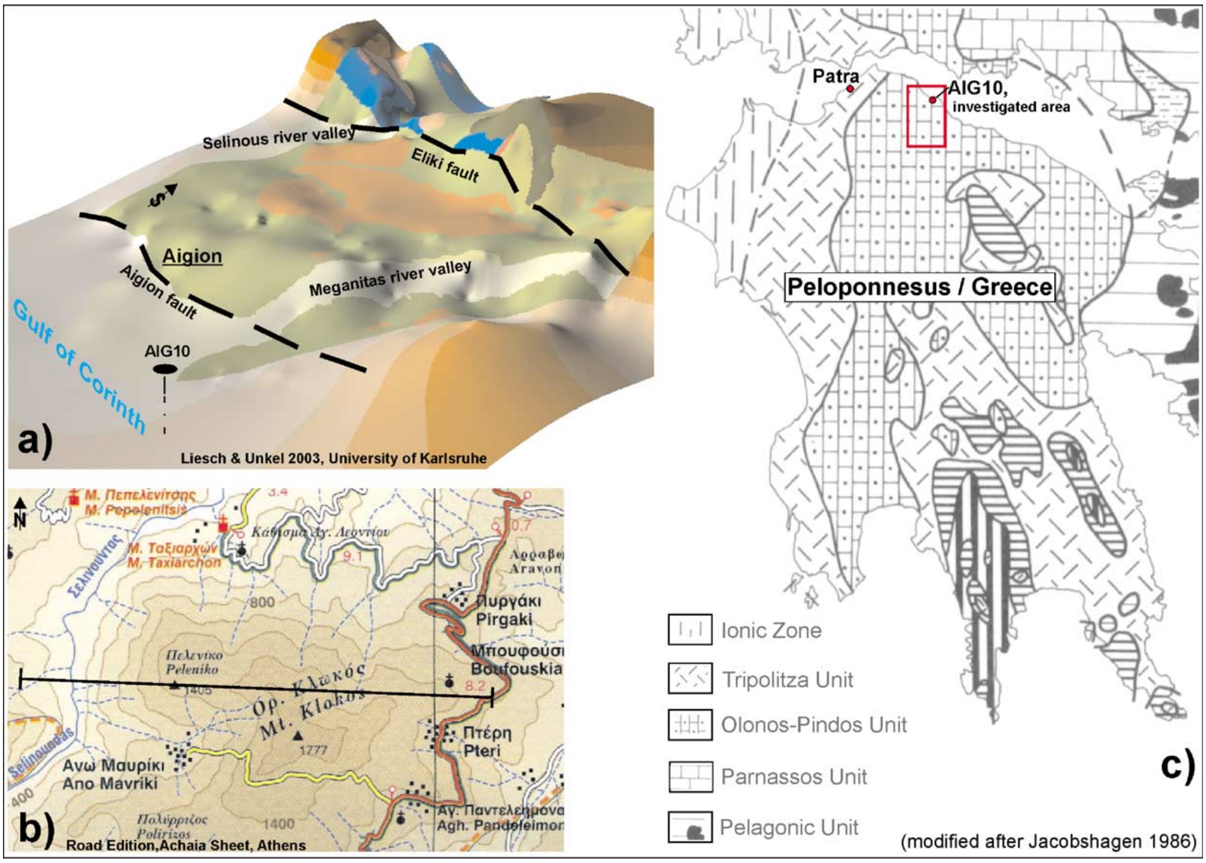

Fig. 1. (**a**) Schematic 3D-map of the Aigion area and location of borehole AIG10 on the southern rim of Corinth rift. (**b**) Location of the cross-section in the Klokos Mountains presented in Fig. 2. (**c**) Tectonic units in Peloponnesus and location of the investigated area.

Fig. 1. (**a**) Carte schématique 3D de la région d'Aigion, avec la localisation du forage AIG10 sur la rive sud du rift du Corinthe. (**b**) Localisation de la coupe transversale (Fig. 2) dans les montagnes du Klokos. (**c**) Unités tectoniques du Péloponnèse et localisation de la région étudiée.

levels ([5,8–10,19], and references therein). The area near Aigion, including the location of the AIG10 borehole, is within the Olonos–Pindos tectonic unit (central Hellenic nappe), which is overthrusted on the Gavrovo–Tripolitza unit, outcropping in the west. To the East, the Pelagonic–Parnassos unit is overthrusted on the Olonos–Pindos unit (Fig. 1). The generally prevailing westward propagation of the thrust nappes also was confirmed by our investigation of the tectonic structures in the hinterland of Aigion and from the structural situation interpreted from unoriented cores taken in the AIG10 borehole [16–18].

The geological structure of the area is defined by thrust faults as well as synthetic and antithetic normal faults. The thrust faults, dipping mostly SSE and connected with WNW-verging folds, are the result of Alpine thrust tectonics [4,9]. North- or south-dipping synthetic and antithetic normal faults were generated during the Miocene/Pliocene–Recent during extension across the Gulf of Corinth [1,12]. The Olonos–Pindos unit is multiply imbricated and overthrusted on the Tripolitza unit. The imbrication, duplex structures as well as thrust folds, investigated also in the hinterland of Aigion (Figs. 1 and 2), are the reason why different stratigraphic sequences alternate, resulting in changes in lithology in a short distance [17]. The tectonic structure and dynamic is a key for interpreting the succession encountered in the AIG10 borehole.

The *normal* non-thrusted succession of the Olonos–Pindos unit shows Triassic clastic sediments (Middle–

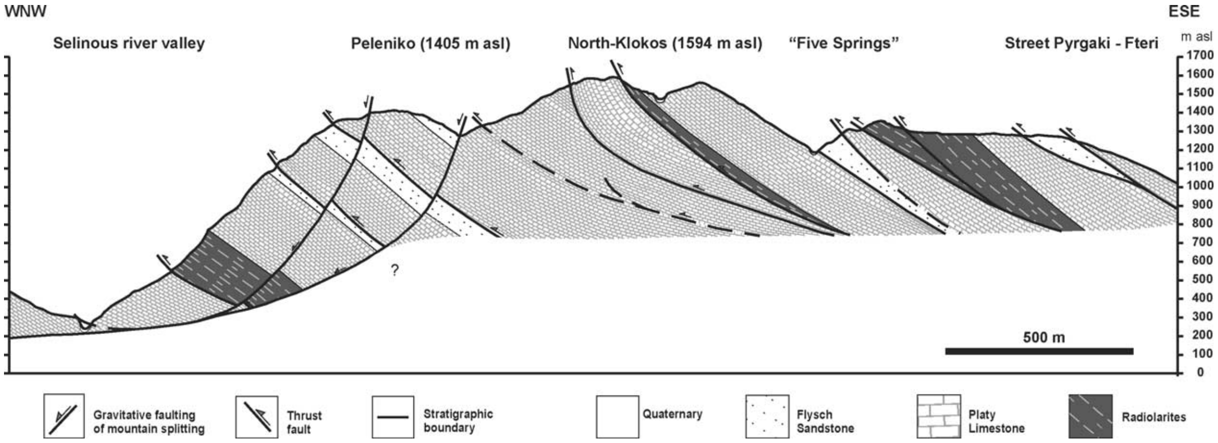

Fig. 2. Cross section of the Alpine overthrusted Olonos–Pindos nappe, mapped and investigated in the Klokos Mountains, approximately 18 km south of the AIG10 borehole. Note that the listric normal faults of the cross section at the Peleniko Mountain are dipping to the west and are related to gravitational mountain collapsing (Selinous river valley) and not to tectonic features. Location in Fig. 1.

Fig. 2. Coupe transversale de la nappe de charriage alpine du Pinde–Olonos, étudiée et cartographiée dans les montagnes du Klokos, approximativement 18 km au sud du forage AIG10. Les failles listriques normales représentées dans la coupe à l'ouest du mont Peleniko plonge vers l'ouest et sont dues à l'affaissement gravitaire de la montagne (vallée du Selinous) et non à la tectonique. Localisation sur Fig. 1.

Upper Triassic Priolithos formation, after [3]) overlain by siliceous limestones (Upper Triassic–Lower Jurassic Drimos formation) [3,6]. However, the latter was not identified during mapping in the area south of Aigion. There also is no evidence of this formation in the cuttings and cores from the AIG10 borehole. Younger formations overlying the Drimos formation in between the Olonos–Pindos Unit are from oldest to youngest (after [3,6]):

– the Jurassic-Lower Cretaceous **Radiolarite formation** (Aalenium–Turon), with red-green banded and deep-red radiolarites, unconformly interlayered with green marls, marlstone and micritic limestone, partly with siliceous slates;
– Cretaceous–Tertiary Olonos–Pindos **Platy Limestone formation** (Coniacian–Palaeocene), with light beige-, crème-coloured pelagic limestone of platy and well-stratified micrites; usually interbedded with different coloured marls, black chert, and siliceous limestone;
– Tertiary **Flysch Sandstone** (Paleocene–Upper Eocene), with gray and greenish micaceous sandstone and siltstone with a flysch character and ichnofossils; transition zone of blue-gray silty marlstone and sandy-silty micrites.

2.2. Post Alpine Units south of Aigion

Above a transgressive contact onto the Olonos–Pindos unit exists a sequence of Miocene/Pliocene **lacustrine-lagoonal, fluvio-lacustrine, and brackish** sands, clays, and marls. They consist of bright yellow, fine sandy and silty layers, interbedded with pebbly sediments and silt that are in most cases interwedged with marine intercalations [11]. These sediments are overlain by consolidated, stiff conglomerates, which represent river delta environment (for example, Selinous and Meganitas Rivers) [15]. These Pliocene–Pleistocene (?) **'Gilbert-type' delta conglomerates** consist of well-rounded limestone, marl, and sandstone detritus as well as subangular radiolarites and cherts eroded from the Olonos–Pindos unit. The top Pleistocene/Holocene units consist of fluviatile, limnic, or terrestrial sediments, with some marine intercalations [7,17].

3. The AIG10 litho-log

Recognition of stratification of units encountered in the AIG10 borehole (Fig. 3) is based on an analysis of well cuttings (0–708.8 m and 787.4–1001 m) [11], on-

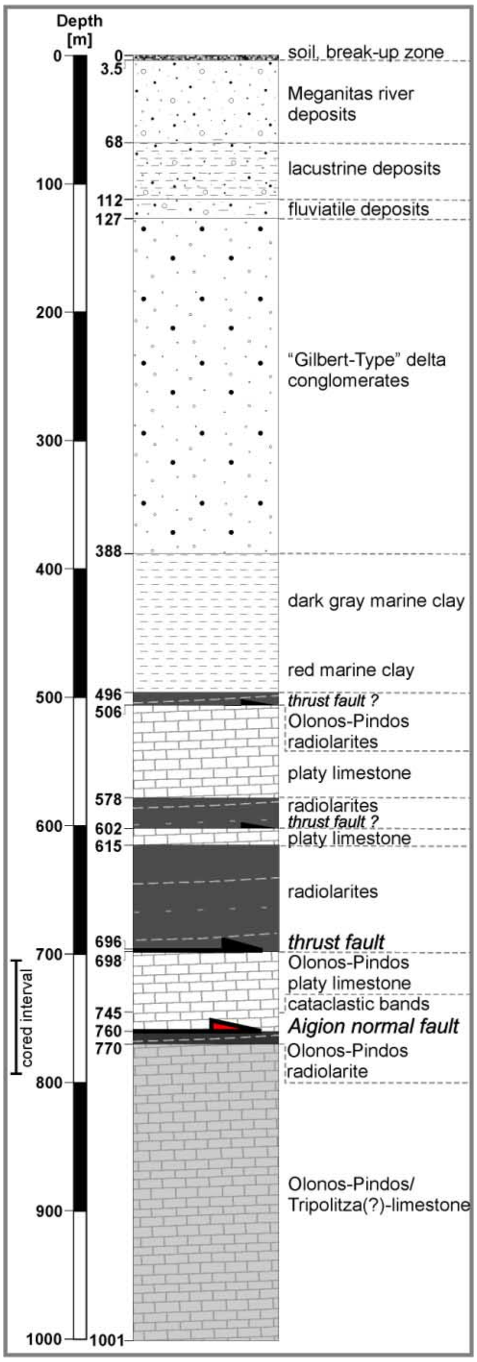

Fig. 3. Generalized litho-log of the AIG10 borehole.

Fig. 3. Litho-log schématique du forage AIG10.

line core descriptions (708.8–787.4 m), monitoring of drilling parameters, as well as a preliminary geophysical well-log interpretation (0–1001 m). A detailed description and interpretation of the syn-rift deposits is given in Lemeille et al. (this issue).

The Corinth graben as recorded in the AIG10 borehole comprises, after Lemeille et al., at least eight units [11]. The succession in AIG10 contains at the top 3.5 m thick argillaceous sandy soil. The following Holocene and Pleistocene sequence (Meganitas River deposits and lacustrine deposits) down to 127 m are characterized by sandy, medium- to fine-grained gravels, intercalated with silty and clayey layers, which can act as aquicludes [7]. These silty clays and marls from 68 m down to 112 m were interpreted by Lemeille et al. as lacustrine deposits, regarding to microorganisms. More detailed descriptions are given in [11], this issue.

From 127 to 388 m, stiff conglomerates were encountered in the borehole, with alternating layers of sand and clay as well as marine intercalations. This 261 m thick sequence consists mainly of well-rounded limestone, marl and sandstone detritus, as well as subangular radiolarites and cherts eroded from the Olonos–Pindos unit, representing a delta environment.

A clayey and sandy transition to marine sediments occurs below this unit, which is underlain by a dark-gray marine clay to a depth of 496 m. The Pleistocene calcareous, fat clay is less silty and contains fossils and nannoplankton, evaluating the age of this sequence. This marine syn-rift deposit could be related to a marine high stand [Mis 5e] in the Late Pleistocene [11]. The dark-gray clay is underlain by a reddish clay sequence, marking the transition to the following succession.

The Radiolarite formation of sharp-edged green and red radiolarites of gravel size in the Olonos–Pindos nappe is encountered at 496 m (Fig. 3). This change in lithology is obvious on the geophysical logs as well as from drilling parameters such as the decrease of the rate of penetration (ROP). The dense radiolarite has a thickness of 10 m and is underlain by limestones intercalated with siliceous marls, analysed from cuttings. With increasing depth, the lithology then repeatedly changes from limestone to radiolarite and marlstone again (Fig. 3, interpreted from cuttings). It has to be assumed that the Jurassic radiolarite, encountered from 496 m down to 506 m, is overthrusted onto the Cretaceous platy limestone. Similar to this assumption are the successions of radiolarite between 578 and 602 m and between 615 and 696 m (Fig. 3). Because of this heterogeneity of the sequence between the depths of 506 and 696 m, it can be assumed that several tectonic contacts exist. At 696–698 m, a main thrust-fault zone was observed, along which the Jurassic radiolarites were overthrusted on Cretaceous limestones. Another indication of the thrust zone is the high content of pieces of calcite crystals in the cuttings, assuming recrystallization and higher water circulation in this zone.

Smaller compressive features like small scaled faulted folds or slipping of less competent intercalations in the succession of the Olonos–Pindos Unit are typical of the lithology, explored on the surface as well as online on the cores from 698 down to 745 m. However, such small-scale features cannot be responsible for the offset of the older radiolarites onto the younger platy limestones.

These results are consistent with observations made on outcrops south of Aigion [17], where thrust-fault zones may show several alternating thrust planes (Fig. 2); well-logging data as Gamma Ray at these particular depths also support this interpretation.

Below the thrust-fault zone at 698 m, the Olonos–Pindos platy-limestone formation was identified by cuttings of light-brown or greenish-gray limestone and marlstone as well as red marl and siliceous marlstone. The first core taken at a depth of 708.8 m confirms the typical character of the well-fractured, slab-shaped Olonos–Pindos platy limestones. The dip of bedding of the platy limestone is southeast and east, possibly indicating a northwest-verging thrust progradation [2].

Below 745 m, the Olonos–Pindos platy limestone shows several cataclastic bands. The first band (at 745.7–746.5 m) is characterized by a well-cemented cataclastic zone with healed calcite veins. Calcite crystals show features of pressure solutions and pressure shadows, whose textures can be interpreted as microkinematic indicators. We interpret this as dip-slip displacement/normal faulting. Another 70 cm thick cataclastic band with less well-healed veins and shear structures was identified in core at 748 m. In contrast to the first two bands, the third band from 754–755 m shows a less compact brecciated zone with open fractures, voids, and geodic cavities, which are filled only partly with calcite. It can be assumed that this cataclastic band is younger than the two previously described because of the stronger brecciated zones and different healed veins. These shear bands and cataclastic zones obviously are part of a major normal fault zone, indicating the Aigion fault. The fourth very strong brecciated cataclastic band was encountered at 756 m and is 4 m thick. This band separates well-fractured platy, micritic limestone from highly fractured radiolarite. At 760 m, the contact between the hangingwall (limestone) and the footwall (radiolarite) dips approximately 55–60° N, which is coherent with the dip of the Aigion fault plane on the surface and at a distance of 470 m to the well. The angle between the bedding of the stratigraphic sequences, dipping southeast and east, and the fault plane, dipping north, is between 80–100° (see also Daniel et al. [2], this issue).

After crossing the fault zone, an increase of water pressure from 5 up to 10 bar was measured (see Giurgea et al. [7], this issue). The highly fractured and brecciated radiolarites as well as the high influx of water caused core losses so that the transition from radiolarite to the underlying limestone could not be located in the cores. However, the geophysical logs indicate the contact to the limestone at 770 m.

The cores from 774 to 787.4 m (end of coring) show that these limestones differ from the micritic limestones of the upper parts of the drilled sequence. Whereas the Olonos–Pindos platy limestones are micrites (pelagic deep sea limestone), the limestones from 770 m downwards are more coarsely crystalline and could be named as calcarenite. They are light gray, with a high content of well-developed calcite crystals. Intercalations of marl and marlstone are very rare. Only some thin, black and marly intercalations were observed. The rock is very porous and has open fractures, large voids, cracks and dissolution structures. The limestone shows no macroscopic fossils. Thin-section analysis and further investigations have to be done to classify the limestones more precisely and to analyse the dolomitic content of the samples.

The cores and the hydraulic behaviour of the deeper intervals down to 1001 m suggest karstification and karstic water-flow conditions [7]. Because of the high influx of water into the well and the high water pressure, the coring had to be stopped at 787.4 m (see [7], this issue) and rotary drilling was continued to a total depth of 1001 m. Cuttings from the last depth interval did not reveal any difference in lithology in relation to the cuttings compared with the last cores. Even though the analysis of cuttings is not as precise than cores, presumably no stronger changes in the lithology of the limestone appears from 787.4 down to the total depth of 1001 m.

4. Conclusions

The lithologic log shows syn-rift deposits of lacustrine, brackish, limnic-lagoonal and deltaic origin, with several marine intercalations down to 496 m. In Lemeille et al. [11] are estimated at least eight different units in this sequence. The conglomerates are composed of detritus from the Olonos–Pindos tectonic nappe. This sequence is followed by dark-grey marine clay, which indicates an anoxic environment. Details of the composition and interpretation of the syn-rift deposits are given in [11] (this issue).

Different interpretations exist about the origin of the clay facies encountered in the well from 388 to 496 m. Lemeille et al. [11] are discussing two assumptions regarding to the black marine clay. They are evaluating this facies as a major marine high stand (MIS 5e) and the contact to the pre-rift Olonos–Pindos Unit as a tectonic one. In a second less preferred assumption, he cited the clay deposits into the MIS 11 c stage, prior to first marine transgressions in the Gulf. Otherwise Moretti et al. [13] interpreted the clay facies from 388 to 496 m more likely as the distal part of the delta environment.

The Olonos–Pindos unit encountered at 496 m was radiolarite and not limestone as would have been expected in a normal non-overthrusted sequence. The tectonic structure and multiple imbrication produce variations in the thickness of the unit. In agreement with several authors, who note the tectonically unaffected 'true' thickness of the Olonos–Pindos unit between 600 and 1500 m, in the Klokos area (Peleniko 1405 m asl) south of Aigion Harbor, and in the AIG10 borehole, a maximum thickness of 800 m was estimated [16–18]. Because of duplex and imbricate structures as well as the overthrusted sequences in between the Olonos–Pindos unit it is difficult to determine the real thickness of the unit in the vicinity of Aigion (Fig. 2).

The first signs of normal faulting in the Olonos–Pindos unit are identified at approximately 745 m. The different cataclastic bands observed are assumed to be of different ages, which is suggested by differential healing of the veins, compaction, porosity and brecciation. The fault zone (756–760 m) is defined by a 4 m-thick intensively brecciated cataclastic zone, which ends in the transition from limestone to radiolarite. Slickensides, observed in the red-clay sequence, need further investigation. Because of the hydraulic behaviour and the strong increase of water pressure, it has to be assumed that the fault zone acts as a hydraulic boundary [7].

The stratigraphic assignment of the lower limestone from 770–1001 m is not clear, because the thickness of the Olonos–Pindos nappe overlying the Tripolitza nappe can vary. At the leading edge of the thrust sheets in the west, near Patra, where the Tripolitza unit plunges under the Pindos unit, the Olonos–Pindos unit is less thick. To the east and the southeast of the Peloponnesus, the tectonic windows (Parnon, Taygetos) show Tripolitza limestones in contact with the Olonos–Pindos limestones [9]. The Olonos–Pindos unit at 496 m in the AIG10 borehole has a succession of 274 m down to 770 m including several thrust faults and a normal fault at 760 m (Fig. 3). Taking the 231 m thick lower limestone (770–1001 m) into account, the sequence would be 505 m thick. Therefore, it is possible that the lower 231 m-thick limestone belongs to the Olonos–Pindos unit. Otherwise, from the lithologic characterization, karstification, and rock properties, however, it is likely that this limestone is part of the Tripolitza unit. If the latter is true, then the sequences must be separated by a main thrust fault at 770 m. The existence of such a thrust fault is supported by the core loss resulting from well-brecciated Olonos–Pindos radiolarites at that depth. To resolve this problem, in-depth investigations on field and core samples of the upper and lower limestones including thin-section analysis will be necessary to decide whether the lower limestone belongs to the Tripolitza Unit.

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