International Ocean Discovery Program Expedition 381 Scientific Prospectus

Corinth Active Rift Development

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Abstract

Continental rifting is fundamental for the formation of ocean basins, and active rift zones are dynamic regions of high geohazard potential. However, much of what we know from the fault to plate scale is poorly constrained and is not resolved at any level of spatial or temporal detail over a complete rift system. For International Ocean Discovery Program Expedition 381, we propose drilling within the active Corinth rift, Greece, where deformation rates are high, the synrift succession is preserved and accessible, and a dense, seismic database provides high-resolution imaging, with limited chronology, of the fault network and of seismic stratigraphy for the recent rift history. In Corinth, we can therefore achieve an unprecedented precision of timing and spatial complexity of rift-fault system development and rift-controlled drainage system evolution in the first 1–2 My of rift history. We propose to determine at a high temporal and spatial resolution how faults evolve, how strain is distributed, and how the landscape responds within the first few million years in a nonvolcanic continental rift, as modulated by Quaternary changes in sea level and climate. High horizontal spatial resolution (1–3 km) is provided by a dense grid of seismic profiles offshore that have been recently fully integrated and are complemented by extensive outcrops onshore. High temporal resolution (~20–50 ky) will be provided by seismic stratigraphy tied to new core and log data from three carefully located boreholes to sample the recent synrift sequence.

Two primary themes are addressed by the proposed drilling integrated with the seismic database and onshore data. First, we will examine fault and rift evolutionary history (including fault growth, strain localization, and rift propagation) and deformation rates. The spatial scales and relative timing can already be determined within the seismic data offshore, and dating of drill core will provide the absolute timing offshore, the temporal correlation to the onshore data, and the ability to quantify strain rates. Second, we will study the response of drainage evolution and sediment supply to rift and fault evolution. Core data will define lithologies, depositional systems and paleoenvironment (including catchment paleoclimate), basin paleobathymetry, and relative sea level. Integrated with seismic data, onshore stratigraphy, and catchment data, we will investigate the relative roles and feedbacks between tectonics, climate, and eustasy in sediment flux and basin evolution. A multidisciplinary approach to core sampling integrated with log and seismic data will generate a Quaternary chronology for the synrift stratigraphy down to orbital timescale resolutions and will resolve the paleoenvironmental history of the basin in order to address our objectives.

Schedule for Expedition 381

Expedition 381 is based on International Ocean Discovery Program (IODP) drilling Proposal 879-Full and Addenda 879-Add and 879-Add2. Following ranking by the IODP Science Advisory Structure, the expedition was scheduled by the European Consortium for Ocean Research Drilling (ECORD) Facility Board as a Mission Specific Platform (MSP) expedition, to be implemented by the ECORD Science Operator (ESO). The expedition is scheduled for October–December 2017, with a total of 56 days available for the drilling, coring, and downhole measurements described in this report and on the ESO Expedition 381 webpage (see below). The onshore science party (OSP) at the IODP Bremen Core Repository (BCR) in Bremen, Germany, is provisionally scheduled to start 31 January 2018 and last for a maximum of 4 weeks (dependent on core recovery).

The following links should be used in conjunction with this *Scientific Prospectus*:

- The Expedition 381 webpage will be periodically updated with expedition-specific information on the platform, facilities, coring strategy, measurements plan, and schedule. The full proposal and addenda can be accessed via this page (**http://www.ecord.org/expedition381**).
- General details about the offshore facilities provided by ESO are provided on the ESO-specific webpages on the MARUM website (**http://www.marum.de/en/Offshore_core_curation_and_measurements.html**).
- General details about the onshore facilities provided by ESO are provided on the ESO-specific webpages on the MARUM website (**http://www.marum.de/Onshore_Science_Party_OSP.html**).
- Supporting site survey data for Expedition 381 are archived in the IODP Site Survey Data Bank (**https://ssdb.iodp.org/SSDBquery/SSDBquery.php**; select P879 for the Proposal number). Please note that not all site survey data associated with this expedition is publicly available.

Introduction

How rifting initiates and evolves to continental breakup and ocean basin formation is a major unanswered solid earth/plate tectonic question; continental rifting is the first stage of this process. Over the last ~15 y, important insights have derived from numerical models (e.g., Burov and Poliakov, 2001; Lavier and Buck, 2002; Lavier and Manatschal, 2006; Huismans and Beaumont, 2007, 2011) and from observations at mature, magma-poor passive margins (Boillot et al., 1987; Reston et al., 1995; Manatschal et al., 2001; Whitmarsh et al., 2001; Osmundsen and Ebbing, 2008) where activity has ceased, but early synrift stratigraphy is often difficult to image and sample due to deep burial and tectonic overprinting. Instead, this project will study the young, seismically active Corinth rift with a unique existing data set to resolve, at high temporal and spatial resolution, how faults initiate and link, how strain is distributed over time, and how the landscape responds during the first few million years of continental rifting. The entire interconnected rift system can be resolved and examined on a range of timescales, and, because the Corinth rift lacks magmatism, the number of variables contributing to rift morphology and stratigraphic fill are reduced. Numerical models indicate that strain rate is a key parameter controlling the style and magnitude of extension, and improved strain rate information will help constrain rheology. However, spatial and temporal patterns in strain rate are very poorly known for most extensional systems due to poor chronological constraints, other than over short (earthquake-cycle) timescales. Key questions include the following: What controls rift geometry and evolution? How does activity on faults change with time, and what are the implications for earthquake activity on a developing rift fault system and what does this tell us about crustal rheology? How do strain rate and distribution control landscape development and sediment flux into rifts? How do sediment flux and landscape evolution influence rift development?

The magnitude, rate, and timing of deformation have rarely been quantified in a continental rift system at a resolution <1 My. The Corinth rift (Figure **F1**) offers the opportunity to do this at a resolution only achievable at a few locations worldwide. The Corinth rift is an ideal target for studying rift processes because it is deforming under high strain rates (e.g., Briole et al., 2000), and extension is focused, with well-constrained initial conditions, a sea level reference frame, and no tectonic overprinting. Corinth is a nonvolcanic, nonoblique rift complementing research in other active rift systems (e.g., East Africa and the Gulf of California). The rift is currently a closed, small-scale clastic sedimentary system, and the last ~2 My of the synrift stratigraphic record is preserved offshore with earlier rift sediments preserved onshore, providing a clear spatial and temporal record of fault and rift activity. Late Quaternary paleoenvironments fluctuated between interglacial Mediterranean-type climates and glacial, cool, wet conditions (Tzedakis et al., 2006), allowing us to examine the impact of climatic change on surface processes (e.g., Collier et al., 2000).

As the focus of extensional deformation within the Aegean Sea, Corinth is one of few actively extending rifts where a near-complete synrift stratigraphic sequence is well preserved and easily accessible, partly onshore and partly offshore. Ocean drilling is the only way to resolve the chronology and paleoenvironment of the offshore synrift succession (only the earlier rift sequence is exposed onshore, with limited dating potential). During this expedition we will drill, sample, and log a significant part of this sequence to constrain in space and time the deformation rate, absolute timing of rifting processes, subsidence and sediment flux through time, and interaction of rift development and climate on surface processes and sediment flux. This project will address the Earth Connections, Earth in Motion, and Climate and Ocean Change aspects of the IODP Science Plan.

Background

The Corinth rift

The Corinth rift (Figure **F1**) is one of Europe's most seismically energetic areas. The Aegean Sea represents a natural laboratory for the study of rapid continental extensional tectonics, with extension beginning in the Oligocene–Miocene (e.g., McKenzie, 1978; Le Pichon and Angelier, 1981; Jolivet et al., 1994; Armijo et al., 1996; Jolivet, 2001). In the late Pliocene–early Pleistocene, deformation became strongly localized across a few zones, with the Corinth rift the most prominent. The active rift is a ~100 × 30–40 km band experiencing north–south extension; the entire rift is ~70–80 km wide. Current extension rates reach 10–16 mm/y (e.g., Clarke et al., 1998; Briole et al., 2000; Bernard et al., 2006), some of the highest in the world, giving strain rates of ~5 × 10^{-7}/y. There is continued debate on the origin of extension in the broader Aegean and focusing of strain at the Corinth rift, with models typically combining gravitational collapse of thickened crust, subduction-driven rollback and backarc extension, westward expulsion of Anatolia and propagation of the North Anatolian fault (e.g., Armijo et al., 1996; Jolivet et al., 2010). Regional lithospheric structure, including that of the underlying subducting African plate, is constrained by wide-angle seismic and teleseismic tomographic techniques and gravity data (e.g., Tiberi et al., 2000; Sachpazi et al., 2007); thicker crust (~40–45 km) runs northwest–southeast along the orogenic Hellenide/Pindos mountain belt in the western rift (Figure **F2**).

Rift evolution and stratigraphy

Corinth rifting began at ~5 Ma with three main phases identified by integrating onshore deposits and offshore seismic stratigraphy (Figure **F3**) (e.g., Armijo et al., 1996; Sachpazi et al., 2003; Ford et al., 2007; Bell et al., 2009; Taylor et al., 2011; Nixon et al., 2016). Initial Pliocene basinal deposition (preserved onshore) was continental, varying from alluvial fans in the west to lakes in the east ("Lower Group"; Ford et al., 2007, 2013; Rohais et al., 2007; Backert et al., 2010). Increased subsidence rates, depocenter deepening, and fault linkage followed, with large marginal fan deltas (locally >800 m thick) now uplifted and exposed onshore ("Middle Group"). The timing of the marked deepening ("rift climax") may have occurred at different times along the rift (e.g., ~2.2 Ma in the Alkyonides Gulf [eastern rift], ~3.0 Ma in the central rift [Leeder et al., 2008, 2012), and ~1.8 Ma in the west [Sackpazi et al., 2003]). This transition is thought to represent increased subsidence and sediment supply into the rift at the location of the modern Gulf of Corinth (Middle Group onshore; probable seismic Unit 1 offshore). During this phase, the rift was controlled by both south- and north-dipping bounding faults (Bell et al., 2009; Ford et al., 2013; Nixon et al., 2016).

At ~0.6 Ma, fault activity stepped northward, and the rift narrowed, establishing the modern rift asymmetry with southern boundary north-dipping faults dominating subsidence and with fan deltas developing along the southern Gulf margin ("Upper Group" onshore; seismic Unit 2 offshore). These faults apparently grew and linked rapidly (Nixon et al., 2016). The rift environment has evolved from terrestrial to lacustrine to alternating lacustrine-marine between glacial–interglacial periods, respectively, as eustatic sea level fluctuated relative to the boundaries of the basin (west: Rion sill; east: Isthmus of Corinth). The exact onset of regular marine deposition is not known but is hypothesized to correlate with the distinct seismic stratigraphy of seismic Unit 2 (earlier limited marine incursions have been described; e.g., Ford et al., 2007, 2013).

The rift appears to narrow as it evolves (strain localization), but it also migrates northward. Geodetic and microseismicity data indicate recent highest strain rates in the western rift (e.g., Avallone et al., 2004; Bernard et al., 2006). However, long-term extensional strain is greatest in the central rift (e.g., Bell et al., 2009, 2011). The extension rate may have increased at specific times over rift history (Ford et al., 2013), suggesting a deviation from models with relatively constant net strain and increasing, gradual localization (McLeod et al., 2000; Sharp et al., 2000; Gawthorpe et al., 2003; Taylor et al., 2004).

Offshore rift architecture and synrift stratigraphy

Extension in the rift changes along axis and in time, with changing polarity and symmetry of fault networks, single versus multiple active faults, and complex depocenter distribution offshore (Figures **F1**, **F4**). Clear, traceable unconformities or sequence boundaries mark major changes in rift development, but their age is unknown.

The synrift succession offshore is locally up to 2.5 km thick and divided into two seismic stratigraphic units separated by a locally angular unconformity (U): the older, lower amplitude seismic Unit 1 and the younger, well-stratified, and higher amplitude seismic Unit 2 (Figures **F5**, **F6**). Seismic Unit 1 includes two different seismic facies that may or may not be stratigraphically distinct: a nonstratified (limited clear reflections) subunit (1a) mainly found on the southern basin margin and a more widespread, stratified (although weakly in places) subunit (1b). Seismic Unit 2 has been interpreted to record glacial–interglacial cycles (Sachpazi et al., 2003; Bell et al., 2008, 2009; Taylor et al., 2011) on the basis of marine and lacustrine conditions detected in short cores, clinoform sequences on some basin margins (e.g., Leeder et al., 2005; McNeill et al., 2005; Lykousis et al., 2007; Bell et al., 2008), and alternating low-amplitude/high-amplitude seismic sequences interpreted as lowstand lacustrine/highstand marine sequences, respectively (e.g., Figures **F5**, **F7**). The integrated sequence stratigraphic interpretations suggest the base of seismic Unit 1 is dated to ~0.6 Ma (Nixon et al., 2016). The onshore Middle Group is thought to be time-equivalent to the lower unit offshore (seismic Unit 1), with the onshore Upper Group equivalent to the upper unit offshore (seismic Unit 2). The onshore Lower Group is likely of minimal thickness offshore, if present at all, because it was north of the locus of rifting at that time.

Depth to basement maps (Bell et al., 2009; Taylor et al., 2011) show a single depocenter below the current central gulf, with reduced subsidence in the eastern (Alkyonides Gulf) and western rifts. Isochore maps of the synrift sediments (Figure **F4**) (Bell et al., 2009; Taylor et al., 2011; Nixon et al., 2016) indicate that before the ~0.6 Ma unconformity separating seismic Units 1 and 2, two primarily symmetric depocenters existed, but since the unconformity, these have linked into a single depocenter, coincident with transfer of strain from south- to north-dipping faults (increased asymmetry) (Figure **F4**). Specifically, a change in rift polarity and symmetry followed by depocenter linkage occurred. The switch to dominant north-dipping faults appears to be broadly synchronous along the entire rift. Since ~200 ka, these north-dipping faults have evolved from linkage of smaller fault segments and increased in size and activity with equivalent changes to depocenters. The timing, position, and rate of switch in rift polarity/symmetry and of fault and depocenter linkage can only be constrained by drilling that provides the chronology combined with the existing dense seismic network.

Scientific objectives

Primary objectives

1. *Fault and rift structural evolution in an active continental rift: to establish the distribution of tectonic strain in time and space and the timescales of fault evolution in a young rift at high resolution (20–50 ky and 1 km to tens of kilometers).*

We will determine the growth and development of a rift-scale normal fault network, timescales of segmentation establishment, basin evolution in terms of strain localization, rift propagation and migration, and the impact of crustal structure and composition on strain rate and distribution. What are the controlling parameters on strain localization? How and when does a "mature" fault network emerge?

2. *Surface processes in active rifts: to determine the evolution of a rift-controlled, closed drainage system in time and space at high temporal resolution (20–50 ky) and the relative impact of tectonics and climate on sediment flux.*

What are the relative contributions of millennial to orbital periodicity Quaternary climate fluctuations (global and regional) and fault activity/rift evolution in controlling the supply of sediment into a rift basin? We will assess changes in sediment flux at a range of timescales and analyze the paleoenvironment of the rift basin through time and then use these results to determine the response to fault birth, death and migration, rift flank uplift, and changes in strain rate (tectonic forcing) in terms of sediment supply and the feedbacks between climate, erosion, sediment transport, and deposition and tectonic processes.

Secondary objectives

3. *To resolve reliable active fault slip rates in order to improve regional earthquake (and secondary tsunami and landslide) hazard assessment.*

The Gulf of Corinth has high levels of seismicity and damaging historic secondary hazards such as slope failure and tsunami in a region of high coastal population density and tourism. Fault slip rates currently rely on paleoseismological and tectonic geomorphological studies of very recent fault slip (the last ~200 ky) and estimated horizon ages for longer timescales. These slip rate estimates include significant uncertainties, and slip rates remain unquantified on many faults. Ocean drilling will allow us to determine fault slip rates on 10–100 ky to 1 My timescales. We will integrate these with shorter timescale data (paleoseismological, geodetic, and seismicity) to more fully understand the seismic hazard potential of individual faults. Cores may also allow us to assess the frequency of major slope failure (integrated with seismically identified mass transport deposits), an indication of seismicity and of secondary hazards.

4. *To generate a new high-resolution record of the Quaternary paleoclimate of the Eastern Mediterranean with respect to global climate and the paleoenvironment of the Corinth basin as a semi-isolated marine-lacustrine basin controlled by changing base level and climate.*

Details of the Corinth basin's changing environment from glacial to interglacial times are poorly known, and the precise timing of transition from lacustrine to partly marine conditions is unconfirmed, as well as the relationship to the interacting controls of basin subsidence, sill elevation, and eustatic sea level. Offshore drilling of synrift sediments will provide a record of regional Quaternary paleoclimate and paleoceanography by sampling pollen, micro-macro fossils, stable isotopes, and sediment physical and chemical properties. Long cores from the Gulf of Corinth would also provide the opportunity to generate (1) the first high-resolution relative paleointensity (RPI) record in the Mediterranean correlated with global RPI stacks (e.g., Valet et al., 2005; Channell et al., 2009) and other RPI curves (Stott et al., 2002; Lund et al., 2005; Channell et al., 2008; Skourtsos and Kranis, 2009) to help understand the dynamics of the geomagnetic field and (2) a linked terrestrial pollen and marine $\delta^{18}O$ record in the Eastern Mediterranean (at least for interglacial intervals) to help constrain age models for existing Eastern Mediterranean long pollen records.

Previous drilling

No previous drilling has been undertaken in the vicinity of the proposed drill sites. Onshore drilling of the Aigion fault and its footwall and hanging wall sediments and basement was undertaken as part of the AIG10 Aigion Fault Drilling Project (Cornet et al., 2004). However, the objectives of this project were different than those of Expedition 381 and focused on fault properties, fault hydrogeology, and installation of well observatories. Offshore, limited long piston cores (up to 30 m penetration) were recovered from the central and eastern area of the Gulf of Corinth during a cruise of the RSS *Marion Dufresne* (using a CALYPSO corer) (Moretti et al., 2004). Interpretation of these piston cores clearly shows the interface between marine and lacustrine (nonmarine) depositional environments; the modern marine sediments mainly consist of hemipelagic mud-silt-sand gravity flow deposits (primarily distal turbidites grading into homogenite, as well as debris flow deposits), whereas the underlying nonmarine sediments (from the last glacial period) include significant packages of thinly laminated, varved muds/clays and lithologies comparable with those logged in the marine sequence (Moretti et al., 2004; Lykousis et al., 2007; Campos et al., 2013). In addition to the long piston cores, a series of shallow piston, box, and gravity cores were recovered from within the Gulf of Corinth and the Alkyonides Gulf, sampling the upper few meters below seafloor (e.g., Collier et al., 2000; Lykousis et al., 2007). Onshore exposures of the earlier synrift sequences provide examples of analogs of some of the lithologies and facies likely to be encountered in the offshore rift (e.g., Collier and Dart, 1991; Dart et al., 1994; Ford et al., 2007, 2013; Rohais et al., 2007).

Proposed drilling

The Gulf of Corinth is entered from the east by the Corinth Canal and from the west by the Rion suspension bridge; the R/V *JOIDES Resolution* cannot pass due to its height, so this expedition was scheduled as a MSP nonriser drilling expedition. Because boreholes deeper than ~750 meters below seafloor (mbsf) would likely require casing, increasing time and cost, the total depth for the deeper sites has been set at 750 mbsf. However, if targets are slightly deeper and hole conditions allow, this depth may be exceeded, and for this purpose Environmental Protection and Safety Panel (EPSP)-approved depths are 950 mbsf for these deeper sites.

The drilling program targets SU2, the unconformity between seismic Units 1 and 2, and the upper part of seismic Unit 1 of the synrift sequence at three sites in the Gulf of Corinth (main basin) and the Alkyonides Gulf basin, with a maximum estimated total depth of ~750 mbsf and total drilling time of up to 56 days. Although the total depth limitation prevents reaching the oldest offshore synrift sediments, by targeting specific sequences in different parts of the rift, we can gain high resolution synrift chronostratigraphy, and by integrating the dated offshore sequences with the partially dated onshore stratigraphy, we can resolve likely age and rift history of the complete synrift sequence. Drilling offshore provides a section that is either not present (Upper Group) or is much more difficult to access (Middle Group) onshore. This drilling program will allow us the potential to resolve the last ~600 ky (seismic Unit 2) of rift and sediment flux history at ultrahigh resolution (10^4 y), constrain the age and nature of the rift-wide unconformity, determine the age and paleoenvironment of much of seismic Unit 1, extrapolate to the base of seismic Unit 1 for its approximate basal age, reach basement and overlying early synrift sediments within the subsidiary Alkyonides Gulf basin, and integrate the offshore and onshore sequences to generate a full synrift history.

Proposed drill sites

Site locations

Three primary sites and three alternate site have been selected, located in water depths ranging from approximately 350 to 850 mbsf and with total penetration depths approximately ≤750 m (Table **T1**).

Sediments are expected to be predominantly Pliocene–Pleistocene turbidites, debris flows, hemipelagic sediments and marls. Seismic Unit 1 is expected to comprise early rift lacustrine, equivalents of the major Gilbert fan deltas exposed onshore (potentially distal and proximal), and potentially fluvial-alluvial sediments, and seismic Unit 2 is expected to comprise alternating lacustrine-marine deposits. Sites were selected based on seismic imaging of potential facies, drilling depth constraints, and drilling time. The sites are located (1) to sample the full upper rift sequence (seismic Unit 2), the prominent unconformity between seismic Units 1 and 2, and the upper section of the lower rift sequence (seismic Unit 1) and (2) on or close to crossing multichannel seismic (MCS) lines that permit ties to the dense grid of MCS and high-resolution data throughout the main basin (Figures **F8**, **F9**).

Site COR-01A

Proposed Site COR-01A (Figure **F10**) is a complete seismic Unit 2 sequence at high resolution with the ability to correlate to even higher resolution expanded seismic stratigraphic sections. Proposed drilling to the regional unconformity (U) and to uppermost seismic Unit 1 sediments.

Site COR-02A

Proposed Site COR-02A (Figure **F11**) is located on a horst block and therefore a more condensed section that will allow access to earlier sections of seismic Unit 1, a near-complete seismic Unit 2, the regional unconformity, and the upper half/third of seismic Unit 1.

Site COR-04B

Proposed Site COR-04B (Figure **F12**) has a relatively thin seismic Unit 2 and targets seismic Unit 1 with the aim of reaching and sampling the uppermost basement and potentially some of the earliest seismic Unit 1 sediments. With proposed Site COR-02A, this site allows direct rift history comparison in two parts of the rift, addressing rift propagation and strain rate history of different parts of the rift through time (e.g., recent strain rates across the Alkyonides Gulf are almost an order of magnitude less than in the main basin [McNeill and Collier, 2004], but has the along-axis strain pattern changed with time?).

Site priority

Our prioritization of sites is (1) Site COR-02A (to achieve a long and high-resolution synrift record), (2) Site COR-01A (late Pleistocene–Holocene rift history at ultrahigh resolution), and (3) Site COR-04B (testing along-axis variations in rift history).

Site survey data

A dense network of seismic reflection profiles (approximately hundreds of meters to 1–3 km spacing) is available from collaborating groups and published material (Figure **F9**; Table **T2**), including deep penetrating lines imaging basement (Sachpazi et al., 2003, 2007; Clément et al., 2004; Zelt et al., 2004, 2005; Taylor et al., 2011) and high-resolution single and multichannel data revealing a detailed sequence stratigraphy of the synrift sequences (Stefatos et al., 2002; Leeder et al., 2005; McNeill et al., 2005; Lykousis et al., 2007; Sakellariou et al., 2007; Bell et al., 2008, 2009). The ability to integrate these data sets and to correlate key horizons and sequences has been demonstrated in recent publications (e.g., Bell et al., 2008, 2009; Taylor et al., 2011). The Virtual Site Survey (VSS) integration project has now fully correlated the stratigraphic sequence and fault network throughout the rift (Nixon et al., 2016). This project also scanned all high-resolution analog seismic data and generated a complete digital seismic interpretation project. Multibeam bathymetry and gravity data are available from throughout the gulf.

Operational strategy

Drilling platform

The proposal for Expedition 381 calls for a drilling platform that can operate in deep water and offer deep penetration. A high-end geotechnical drilling vessel, the Fugro *Synergy*, that is capable of automated double stand rod handling, has been contracted to undertake the drilling and coring. Coring will be performed using soil boring equipment through a center moonpool using a top drive power swivel. The equipment includes a fixed twin-tower ram rig (R190), a mud mixing and pumping unit, and other tools and accessories required to carry out the site investigation. The rig incorporates a heave motion compensator to ensure the drill bit maintains a uniform pressure on the base of the borehole during drilling operations. The SEADEVIL (a device that clamps the drill string and controls the bit weight and rate of penetration at the seabed, independent of the vessel heave) is installed in the seabed frame for improved depth control during drilling. An ample supply of drilling mud will be provided, and a spare string of drill pipe, sufficient spare parts, and other supplies required will be available. The work is to be performed in drilling mode using American Petroleum Institute (API) pipe and seawater or drilling mud (Bentonite).

The seabed frame will also be fitted with a pipe clamp (incorporated in the SEADEVIL) to immobilize the drill string and minimize sediment disturbance during sampling and testing. Upon completion of a borehole, the pipe will be withdrawn and the seabed frame will be lifted into the moonpool.

Downhole depth control

Prior to commencing drilling operations, water depth will be measured at and reduced to local (observed) mean sea level (MSL). Water depth measurements will be performed using the drill string lowered onto the clamps in the seabed frame and a vessel-mounted echo sounder.

At this time, the “air gap” (i.e., the distance between the drill floor and the water level in the moonpool) will be measured to assist with the accurate determination of the drill bit depth below seafloor. The air gap will be checked periodically during the site investigation and specifically after port calls or long periods of inactivity offshore where fuel/water levels may affect the draught of the vessel.

Coring methodology

Two suites of coring tools are available, a Fugro suite (Fugro Wison EP system, Fugro Corer, and Fugro Extended Marine Core Barrel [FXMCB] corer) and DOSECC suites (Hydraulic Piston Corer Alien Barrel, Extended Nose Sampler, and Extended Alien Barrel).

The first borehole will start with the Fugro suite. Of the two suites, the Fugro tools are predicted to provide the highest quality and the fastest coring rate in the anticipated formations. Coring will commence using the Fugro Piston Sampler, and it will be used until the penetration rate consistently drops below 2 m or the quality drops; this point is anticipated to be between 75 and 100 mbsf. The Fugro Corer, used in push mode, will then be employed and used until the penetration and/or quality of the cores reach the limitation of the corer, ideally at the base of the borehole. The FXMCB corer, a diamond rotary corer, will be used once the limitations of the Fugro Corer are reached; this tool will be used until the base of the hole but may be interspersed with the Fugro Corer as ground conditions change.

The quality and percent recovery will be constantly monitored, and the tool operation will be adjusted to the local ground conditions. This constant feedback will aid both the quality of the first borehole and subsequent strategy for boreholes 2 and 3.

The DOSECC suite tools are also available should the Fugro tools not perform or the formation is not as anticipated.

Cores will be obtained in clear polycarbonate liners.

Sampling regime

The expedition’s sampling regime is as follows:

- Continuous sampling regime, where possible.
- Downhole temperature measurements from a cone penetration test to be used at ~100 m intervals to ~300 m penetration at each site.
- Any alternate sequence adjusted to suit operations and site-specific conditions.

Typically, the maximum core run will be between 3 and 4.5 m long, depending on the coring tool used. However, shorter core runs can be made if the formation is blocking the bit or it is too friable to withstand a 3 m run.

Downhole logging

For all MSP expeditions, the downhole logging program, coordinated by the European Petrophysics Consortium (EPC), is an integral part of the offshore operation and is designed to help meet the expedition-specific scientific objectives and maximize scientific output in general.

The various coring strategies and resulting logging conditions (e.g., water depth and pipe and borehole diameter) on MSPs require an appropriate set of logging tools. The type of logging tools used, including super-slimline tools, memory-mode tools, and standard oilfield tools, varies from expedition to expedition.

For each hole, the first in situ measurement will be downhole temperature, which is acquired during coring operations with a cone penetration test. Logging tools will be deployed in each hole once the target or maximum depth has been reached. For Expedition 381, logging services are contracted to the University of Montpellier (France). Their suite of super-slimline tools can be used alone or stacked in a tool string, offering the possibility to collect multiple measurements in a single tool string run. During the project, the Petrophysics Staff Scientist will liaise with the Co-Chief Scientists, Expedition Project Manager, operational team, science party, and logging engineers to ensure that the best decisions are made to address the scientific objectives, taking into consideration both time constraints and borehole conditions.

The tool suite available for Expedition 381 includes spectral and total gamma ray, *P*-wave sonic velocity, *S*-wave sonic velocity, acoustic and optical borehole imaging, electrical resistivity, magnetic susceptibility, hydrogeological measurements (fluid conductivity, pH, eH, temperature, and dissolved oxygen), caliper, and flow meter.

For Expedition 381, the plan is to acquire downhole logging data at each of the sites drilled. To address the scientific objectives, spectral gamma ray, *P*-wave sonic velocity, and magnetic susceptibility are the highest priority measurements. As is common for IODP logging programs, measurements will be acquired via a series of logging runs in each hole logged, should borehole conditions allow. The hole will be logged in depth stages (initially in 250 m intervals from base to top) to maximize the ability to acquire data where the borehole may be unstable. Configuration of the tool strings deployed will be modified depending on the stability of the hole and operational progress. The provisional downhole logging program is detailed below (but may be subject to change):

- Through-pipe: spectral gamma ray (standalone).
- Open hole: conductivity + magnetic susceptibility; resistivity (standalone); gamma ray + sonic + acoustic televiewer (stacked); gamma ray + caliper + magnetic susceptibility (stacked); and/or spectral gamma ray with precise details dependent on hole stability, data quality from previous runs, and time.

The Petrophysics Staff Scientist will be responsible for data processing, Quality Assurance/Quality Control (QA/QC) of data, and ongoing scientific support for data interpretation and research. The final set of downhole data (following the full QA/QC process) will be made available to the science party at the commencement of the OSP.

Site priorities and contingency considerations

The planned order of sites is proposed Sites COR-02A, COR-01A, and COR-04B; however, this order is subject to change based on drilling conditions and time. Site COR-02A was chosen as the first site because it will sample the longest time record within the main basin of the Gulf of Corinth, including a significant part of the synrift sediments from the earlier seismic Unit 1. Site COR-01A will provide an expanded, more complete section of seismic Unit 2 than Site COR-02A in the main basin, which is essential for reconstructing a high-resolution record of tectonic and sedimentary history. Site COR-01A following COR-02A is also efficient in terms of transit. Finally, we plan to drill Site COR-04B in the Alkyonides Gulf basin to provide spatial coverage and a test of spatial rift history variation.

Based on what is known about the likely lithologies that will be encountered in these sites, it is possible that recovery could be poor in some intervals. If recovery is poor, the Co-Chief scientists, Expedition Project Manager, and operational team could consider other coring tools. If recovery in the uppermost section is poor, additional shallow holes may be drilled to sample this key interval because it can provide useful Holocene and latest Pleistocene data for geohazards, earthquake history, and recent environmental change. If recovery of key horizons (e.g., the seismic Unit 1/2 unconformity) or other key intervals is particularly poor, we would consider drilling an additional nearby hole and drilling through the overlying section without coring to attempt to obtain better sampling of the interval in question. Particularly in the case that the same time interval is poorly sampled by multiple sites (e.g., at Sites COR-02A and COR-01A), drilling an additional hole would be considered. We will continually apply lessons learned during the expedition about the most effective coring strategies to improve efficiency or recovery, and, if time allows, this process could result in additional holes. The logging plan may vary based on hole conditions and time available. A full suite of logging runs is planned, but the number may be reduced to priority logs if conditions suggest only limited logging will be possible. If conditions are poor but time allows, a dedicated logging hole could be drilled.

Core on deck

As cores are recovered to deck, they will undergo initial labeling and sampling on a core bench prior to delivery to the curation container. The operation will proceed using a changeover of inner core barrels to ensure continuity of the coring operation in as timely a fashion as possible. The deck operators will deploy an empty core barrel immediately after the previous one has been retrieved and then address the core removal and subsequent readying of that core barrel for reuse. The cores will be collected in plastic liners, so the usual IODP curation procedures will be followed and documented in the ESO Expedition 381 Core Curation, Initial Sampling, and Analyses Handbook. After curation (and temperature equilibration), unsplit core sections and core catcher materials will be passed to the science party for onboard description, physical properties measurements, analysis, and sampling.

Science operations

A Sampling and Measurements Plan (SMP) for Expedition 381 was prepared by ESO and the Co-Chief Scientists to meet the scientific objectives of IODP Proposal 879-Full and Addenda 879-Add and 879-Add2.

Offshore science activities

For MSP expeditions, there is limited laboratory space and accommodation on the platforms compared to the larger research vessels *JOIDES Resolution* and *Chikyu*, and as such there is no splitting of the cores at sea and only selected scientific analysis carried out onboard by a subset of the science party (in this case, nine members). Science activities on the platform are confined to those essential for decision making at sea, core curation, measurement of ephemeral properties, securing of samples for pore water chemistry, and downhole logging. Cores will typically be cut into 1.5 m lengths for curation. Most of the scientific analyses are carried out during the OSP in Bremen, when the cores are split.

The following is a summary of the offshore scientific activities (please refer to **https://www.marum.de/en/Research/Exp.-381-sampling-and-measurement-plan.html** and the online tutorial at **http://www.marum.de/en/Offshore_core_curation_and_measurements.html**):

- Performing basic curation and labeling of core.
- Measuring all cores (>10 cm) on the multisensor core logger (MSCL; gamma density, *P*-wave velocity, electrical resistivity, magnetic susceptibility, and natural gamma radiation).
- Describing and sampling the core catcher (CC), if available, for initial sedimentological, micropaleontological, petrophysical, and/or structural characterization, including taking a CC image.
- Taking and properly storing samples for gas analyses and acquiring and splitting pore water samples.
- Analyzing pore water geochemistry and any other ephemeral properties agreed in the SMP.
- Storing cores.
- Completing downhole logging.
- Calculating preliminary core-log-seismic integration using available downhole logging data and/or core physical properties data.
- Completing associated data management of all activities (see below).

To deliver the scientific requirements on the platform with a subset of the science party, a staffing plan was devised. The plan requires flexibility of approach from all participants, with priority given to safety, core recovery, curation, and procedures for the measurement of ephemeral properties.

Report preparation will take place on board as required:

- Daily and weekly operational reports will be compiled by ESO and provided to the management and panels of ECORD and IODP, science party members, and any other relevant parties. Scientific reports will be provided by the Co-Chief Scientists. Summarized daily reports will be publicly available on the ESO website for any interested parties.
- The offshore science party members and ESO staff will complete the offshore sections of the Expedition Reports (primarily the Methods chapter, but also recording initial results from offshore observations, measurements, and analyses).
- The ESO Outreach Team will complete press releases in line with the ECORD outreach policy and will post information on the ESO expedition website.

Onshore science activities

The OSP will be held at the BCR of the MARUM, Center for Marine Environmental Sciences, at the University of Bremen, Germany. The scientific work will follow the SMP that will be developed in conjunction with the Co-Chief Scientists. The majority of the scientific reporting for the expedition is also undertaken during the OSP by science party members.

Details of the facilities that will be available for the OSP at the BCR and MARUM laboratories can be found at the Expedition 381 SMP link (**https://www.marum.de/en/Research/Partner-to-the-ECORD-Science-Operator.html**). The SMP will take account of MSP specifications for QA/QC procedures. Additional facilities can be made available through continuing close cooperation with additional laboratories at MARUM and the Department of Geosciences at the University of Bremen, all of which are situated nearby on campus.

The following briefly summarizes the OSP scientific activities:

- Prior to the OSP, thermal conductivity measurements will be taken on all cores (as appropriate) using a needle probe. Additional standard IODP physical properties measurements may be undertaken on whole cores at this time in the event offshore data sets are incomplete owing to time (natural gamma radiation) or permitting issues (gamma density). These measurements will be undertaken by ESO personnel.
- Core splitting: an archive half will be set aside as per IODP procedure.
- Core description: For data entry, ESO will employ the Expedition Drilling Information System (DIS), which is entirely compatible with others being used in IODP (see **Data management**).
- High-resolution digital imaging will be completed using a digital linescan camera system.
- Color reflectance spectrophotometry will be completed using a spectrophotometer.
- *P*-wave velocities will be measured on discrete samples using an MSCL Discrete *P*-Wave system (MSCL-DPW).
- Moisture and density (MAD) will be measured on discrete samples using a pycnometer.
- Core sampling for expedition (“shipboard”) samples (to produce IODP measurements data for the Expedition Reports, e.g., petrophysical properties, *P*-wave, and MAD analyses).
- Smear slide preparation will be undertaken by sedimentologists and/or micropaleontologists at regular intervals as required.
- Thin section preparation will be performed (as requested);
- Biostratigraphy will be studied.
- Inorganic geochemistry (whole-rock and pore fluid chemistry) and organic geochemistry will be studied.
- Bulk mineralogy: X-ray diffraction (XRD) analysis will be completed.
- Paleomagnetic measurements will be taken.
- Core sampling for personal postexpedition research: a detailed sampling plan will be devised after the scientists have submitted their revised sample requests following completion of the offshore phase (see **Research planning: sampling and data sharing strategy**). Sampling will likely include whole-round samples for experimental postcruise analysis taken prior to splitting the cores. Sample allocation will be determined by the Sample Allocation Committee (SAC; see below).

In view of the existing geographical distribution of all Deep Sea Drilling Program (DSDP)/Ocean Drilling Program (ODP)/Integrated Ocean Drilling Program/IODP cores, the BCR will be the long-term location for the Expedition 381 cores.

Report preparation will take place during the OSP as required by ECORD:

- Weekly progress reports to ECORD and relevant parties (scientific reports are provided by the Co-Chief Scientists).
- Preliminary Report compiled by the science party (submission to JRSO publication at the end of the OSP).
- The Expedition Reports compiled by the science party (submission to JRSO publication services as soon as practically possible after the OSP).

For more information, please refer to SMP link (above) and the online tutorial at **http://www.marum.de/Onshore_Science_Party_OSP.html**.

Staffing

Scientific staffing is determined on the basis of task requirements and nominations from the IODP Program Member Offices (**http://www.iodp.org/program-member-offices**). ESO staffing is based on the need to carry out the drilling and scientific operations safely and efficiently (Table **T3**).

Data management

A data management plan for the expedition will be developed once the data requirements and operational logistics are finalized. The outline plan is as follows:

- The primary data capture and management system will be the Expedition DIS, a relational database that will capture drilling, curation, and geoscience metadata and data during the offshore and onshore phases of the expedition.
- The Expedition DIS includes tools for data input, visualization, report generation, and data export.
- The database can be accessed directly by other interpretation or decision-making applications if required.
- A file server will be used for the storage of data not captured in the database (e.g., documents and image files) and the inputs/outputs of any data processing, interpretation, and visualization applications used during the expedition.
- On completion of the offshore phase of the expedition, the Expedition DIS database and the file system will be transferred to the BCR to continue data capture during the OSP.

- Between the end of the offshore phase and the start of the OSP, the expedition scientists will have access to the data via a password-protected website.
- On completion of the OSP, expedition scientists will have continued access to all data through a password-protected website throughout the moratorium period.
- During the moratorium, all metadata and data, apart from downhole logging data, will be transferred to PANGAEA for long-term archiving.
- The Petrophysics Staff Scientist will manage the downhole logging data (including formation temperature measurements), MSCL data, and other physical properties data.
- Downhole logging data will be stored separately for processing and compositing and will be made available to the science party via the Log Database hosted by the Lamont-Doherty Earth Observatory (LDEO). These data will be archived at LDEO.
- After the moratorium, cores and samples will be archived at the BCR.
- After the moratorium, all expedition data will be made accessible to the public.

Outreach

The ECORD Outreach and Education Task Force (E-OETF) will be working to promote the expedition and the science generated by this investigation into active rift development. As guidance, the E-OETF produced a communications plan that will be distributed to the science party prior to sailing. The main objectives are as follows:

- To interact positively with the media, non-governmental organizations, governments, and the general public to demonstrate the benefits of the IODP Corinth Active Rift Development scientific expedition and IODP in general.
- To maximize the expedition's publicity impact among scientists and the public.
- To ensure that all outreach is conducted in a consistent way.
- To promote scientific research in respect to the scientific goals.
- To strengthen links between the IODP/ECORD community and the international media.
- To successfully continue the media relationships established during the previous seven ECORD MSP and other IODP expeditions.

To facilitate the above, there will be a number of outreach activities conducted throughout the expedition.

The following outreach activities will take place before the start of the expedition:

- Develop a detailed Communications Plan in close cooperation with Co-Chief Scientists and ECORD/ESO staff, especially the Expedition Project Manager(s).
- Produce and distribute an expedition flier.
- Produce a media pack on the ESO website, including the expedition's webpage and biographies of the Co-Chief Scientists and other members of the science party.
- Organize start-up media briefings in Corinth.
- Distribute an international media release in parallel with the start-up media briefing.
- Organize ship visits for the media during mobilization in Greece, if possible.
- Prepare an outreach document for the science party, explaining their responsibilities.
- Produce a "frequently asked questions" document to distribute to the science party.
- Produce a guide to social media to distribute to the science party.
- Network with participants' university media offices, particularly the Co-Chief Scientists' host organizations.
- Produce an official expedition logo for use on all promotional materials.

The following outreach activities will take place during the offshore phase of the expedition:

- Maintain daily/weekly expedition logbook on ESO website (coordinated by ESO Outreach Manager).
- Publish media releases (in the case of special events/findings and, if appropriate, at the end of the expedition).
- Organize video coverage of the working processes on board the expedition vessel (B-roll footage), to be collected by ESO staff and science party members when time allows.
- Promote the expedition through national and international media and organize interviews with Co-Chief Scientists and other science party members as necessary/requested.
- Promote social media blogs compiled by science party and ESO members.
- Collate photographs that document the entire expedition with the view to putting together a touring photographic exhibition.
- Facilitate Ask Me Anything (AMA) Reddit sessions from offshore and onshore. Possible live link into the North American Electric Reliability Corporation (NERC) showcase event UnEarthed being held at Our Dynamic Earth in Edinburgh, Scotland (UK), on 17–20 November 2017 and also at the ECORD Council Meeting on 24–25 October.

An ESO member of the outreach team will likely sail for the first phase of the expedition to document activities and acquire footage and material for further outreach and educational activities.

The following outreach activities will take place during the OSP (February 2018):

- Prepare background material to provide to the media.
- Hold a media day toward the end of the OSP and invite key journalists and TV teams.
- Publish an international media release (tentative results).
- Facilitate involvement of science communicators for a portion of the OSP, where project appropriate.
- Document activities with photos and video footage.

The following outreach activities will take place after the expedition:

- Promotion at international conferences (booths and talks), for example at the European Geosciences Union (EGU) and American Geophysical Union (AGU) Fall and Ocean Sciences Meetings.
- Promotion of the science through development of educational resources in collaboration with teachers, science communicators, and national organizations/visitor attractions and museums. At the time of publication, arrangements have been formalized with Our Dynamic Earth, UK, and the Edinburgh International Science Festival, and identification of future international opportunities is ongoing.
- General outreach to the media as scientific results of the expedition become available.

- Continued logging of any outreach activities undertaken by any of the science party members including interviews, blogs, and abstracts submitted. The ESO outreach team will depend on science party members to alert us to anything they do in addition to ESO setting up an Agility Alert for the expedition, which will scan all printed media globally.

Research planning: sampling and data sharing strategy

All researchers requesting samples should refer to the IODP Sample, Data, and Obligations Policy & Implementation Guidelines posted at **http://www.iodp.org/program-documents**. This document outlines the policy for distributing IODP samples and data to research scientists, curators, and educators. The document also defines the obligations that sample and data recipients incur. The Sample Allocation Committee (SAC; composed of the Co-Chief Scientists, Expedition Project Manager, and IODP Curator for Europe [BCR and MSPs] or offshore curatorial representative) will work with the entire science party to formulate an expedition-specific sampling plan for "shipboard" (expedition: offshore and OSP) and postexpedition (personal research) sampling.

Members of the science party are expected to carry out scientific research for the expedition and publish it. Before the expedition, all members of the science party are required to submit research plans and associated sample/data requests via the IODP Sample and Data Request system at **http://web.iodp.tamu.edu/sdrm** before the deadline specified in their invitation letters. Based on sample requests submitted by this deadline, the SAC will prepare a tentative sampling plan that can be revised on the ship and once cores are split as dictated by recovery and expedition objectives. All postexpedition research projects should provide scientific justification for desired sample size, numbers, and frequency. The sampling plan will be subject to modification depending upon the material recovered and collaborations that may evolve between scientists during the expedition. This planning process is necessary to coordinate the research to be conducted and to ensure that the scientific objectives are achieved. Modifications to the sampling plan and access to samples and data during the expedition and the 1 year postexpedition moratorium period require the approval of the SAC.

Offshore sampling will be restricted to that necessary for acquiring ephemeral data types that are critical to the overall objectives of the expedition and to preliminary lithologic and biostratigraphic sampling to aid decision making at sea and planning for the OSP.

The permanent archive halves are officially designated by the IODP curator for BCR and MSPs. All sample frequencies and volumes must be justified on a scientific basis and will depend on core recovery, the full spectrum of other requests, and the expedition objectives. Some redundancy of measurement is unavoidable, but minimizing the duplication of measurements among the shipboard party and identified shore-based collaborators will be a factor in evaluating sample requests.

If critical intervals are recovered, there may be considerable demand for samples from a limited amount of cored material. A sampling plan coordinated by the SAC will be required before critical intervals are sampled.

The SAC strongly encourages, and may require, collaboration and/or sharing among the shipboard and shore-based scientists so that the best use is made of the recovered core. Coordination of postexpedition analytical programs is anticipated to ensure that the full range of geochemical, isotopic, and physical property studies are undertaken on a representative sample suite. The majority of sampling will take place at the OSP in Bremen, and the SAC encourages scientists to start developing collaborations before and during the expedition.

References

Armijo, R., Meyer, B., King, G.C.P., Rigo, A., and Papanastassiou, D., 1996. Quaternary evolution of the Corinth Rift and its implications for the Late Cenozoic evolution of the Aegean. *Geophysical Journal International,* 126(1):11–53. **https://doi.org/10.1111/j.1365-246X.1996.tb05264.x**

Avallone, A., Briole, P., Agatza-Balodimou, A.M., Billiris, H., Charade, O., Mitsakaki, C., Nercessian, A., Papazissi, K., Paradissis, D., and Veis, G., 2004. Analysis of eleven years of deformation measured by GPS in the Corinth Rift Laboratory area. *Comptes Rendus Geosciences,* 336(4–5):301–311. **https://doi.org/10.1016/j.crte.2003.12.007**

Backert, N., Ford, M., and Malartre, F., 2010. Architecture and sedimentology of the Kerinitis Gilbert-type fan delta, Corinth Rift, Greece. *Sedimentology,* 57(2):543–586. **https://doi.org/10.1111/j.1365-3091.2009.01105.x**

Bell, R.E, McNeill, L.C., Bull, J.M., and Henstock, T.J., 2008. Evolution of the offshore western Gulf of Corinth. *Geological Society of America Bulletin,* 120(1–2):156–178. **https://doi.org/10.1130/B26212.1**

Bell, R.E., McNeill, L.C., Bull, J.M., Henstock, T.J., Collier, R.E.L., and Leeder, M.R., 2009. Fault architecture, basin structure and evolution of the Gulf of Corinth Rift, central Greece. *Basin Research,* 21(6):824–855. **https://doi.org/10.1111/j.1365-2117.2009.00401.x**

Bell, R.E., McNeill, L.C., Henstock, T.J., and Bull, J.M., 2011. Comparing extension on multiple and depth scales in the Corinth Rift, central Greece. *Geophysical Journal International,* 186(2):463–470. **https://doi.org/10.1111/j.1365-246X.2011.05077.x**

Bernard, P., Lyon-Caen, H., Briole, P., Deschamps, A., Boudin, F., Makropoulos, K., Papadimitriou, P., Lemeille, F., Patau, G., Billiris, H., Paradissis, D., Papazissi, K., Castarède, H., Charade, O., Nercessian, A., Avallone, A., Pacchiani, F., Zahradnik, J., Sacks, S., and Linde, A., 2006. Seismicity, deformation and seismic hazard in the western rift of Corinth: new insights from the Corinth Rift Laboratory (CRL). *Tectonophysics,* 426(1–2):7–30. **https://doi.org/10.1016/j.tecto.2006.02.012**

Bintanja, R., and van de Wal, R.S.W., 2008. North American ice-sheet dynamics and the onset of 100,000-year glacial cycles. *Nature,* 454(7206):869–872. **https://doi.org/10.1038/nature07158**

Boillot, G., Recq, M., Winterer, E.L., Meyer, A.W., Applegate, J., Baltuck, M., Bergen, J.A., Comas, M.C., Davies, T.A., Dunham, K., Evans, C.A., Girardeau, J., Goldberg, G., Haggerty, J., Jansa, L.F., Johnson, J.A., Kasahara, J., Loreau, J.P., Luna-Sierra, E., Moullade, M., Ogg, J., Sarti, M., Thurow, J., and Williamson, M., 1987. Tectonic denudation of the upper mantle along passive margins: a model based on drilling results (OPD Leg 103, western Galicia margin, Spain). *Tectonophysics,* 132(4):335–342. **https://doi.org/10.1016/0040-1951(87)90352-0**

Briole, P., Rigo, A., Lyon-Caen, H., Ruegg, J.C., Papazissi, K., Mitsakaki, C., Balodimou, A., Veis, G., Hatzfeld, D., and Deschamps, A., 2000. Active deformation of the Corinth Rift, Greece: results from repeated global positioning system surveys between 1990 and 1995. *Journal of Geophysical Research: Solid Earth,* 105(B11):25605–25625. **https://doi.org/10.1029/2000JB900148**

Burov, E., and Poliakov, A., 2001. Erosion and rheology controls on synrift and postrift evolution: verifying old and new ideas using a fully coupled numerical model. *Journal of Geophysical Research: Solid Earth,* 106(B8):16461–16481. **https://doi.org/10.1029/2001JB000433**

Campos, C., Beck, C., Crouzet, C., Carillo, E., Van Welden, A., and Tripsanas, E., 2013. Late Quaternary paleoseismic sedimentary archive from deep central Gulf of Corinth: time distribution of inferred earthquake-induced layers. *Annals of Geophysics,* 56(6):S0670. **https://doi.org/10.4401/ag-6226**

Channell, J.E.T., Hodell, D.A., Xuan, C., Mazaud, A., and Stoner, J.S., 2008. Age calibrated relative paleointensity for the last 1.5 Myr at IODP Site U1308 (North Atlantic). *Earth and Planetary Science Letters,* 274(1–2):59–71. **https://doi.org/10.1016/j.epsl.2008.07.005**

Channell, J.E.T., Xuan, C., and Hodell, D.A., 2009. Stacking paleointensity and oxygen isotope data for the last 1.5 Myr (PISO-1500). *Earth and Planetary Science Letters,* 283(1–4):14–23. **http://dx.doi.org/10.1016/j.epsl.2009.03.012**

Charalampakis, M., Lykousis, V., Sakellariou, D., Papatheodorou, G., and Ferentinos, G., 2014. The tectono-sedimentary evolution of the Lechaion Gulf, the south eastern branch of the Corinth graben, Greece. *Marine Geology,* 351:58–75. **https://doi.org/10.1016/j.margeo.2014.03.014**

Clarke, P.J., Davies, R.R., England, P.C., Parson, B., Billiris, H., Paradissis, D., Veis, G., Cross, P.A., Denys, P.H., Ashkenazi, V., Bingley, R., Kahle, H.-G., Muller, M.-V., and Briole, P., 1998. Crustal strain in central Greece from repeated GPS measurements in the interval 1989–1997. *Geophysical Journal International,* 135(1):195–214. **https://doi.org/10.1046/j.1365-246X.1998.00633.x**

Clément, C. Sachpazi, M., Charvis, P., Graindorge, D., Laigle, M., Hirn, A., and Zafiropoulos, G., 2014. Reflection–refraction seismics in the Gulf of Corinth: hints at deep structure and control of the deep marine basin. *Tectonophysics,* 391(1–4):97–108. **https://doi.org/10.1016/j.tecto.2004.07.010**

Collier, R.E.L., and Dart, C.J., 1991. Neogene to Quaternary rifting, sedimentation and uplift in the Corinth Basin, Greece. *Journal of the Geological Society,* 148(6):1049–1065. **https://doi.org/10.1144/gsjgs.148.6.1049**

Collier, R.E.L., Leeder, M.R., Trout, M., Ferentinos, G., Lyberis, E., and Papatheodorou, G., 2000. High sediment yields and cool, wet winters: test of last glacial paleoclimates in the northern Mediterranean. *Geology,* 28(11):999–1002. **https://doi.org/10.1130/0091-7613(2000)28<999:HSYACW>2.0.CO;2**

Cornet, F.H., Bernard, P., and Moretti, I., 2004. The Corinth Rift Laboratory. *Comptes Rendus Geoscience,* 336(4–5):235–241. **https://doi.org/10.1016/j.crte.2004.02.001**

Dart, C.J., Collier, R.E.L., Gawthorpe, R.L., Keller, J.V.A., and Nichols, G., 1994. Sequence stratigraphy of (?)Pliocene–Quaternary synrift, Gilbert-type fan deltas, northern Peloponnesos, Greece. *Marine and Petroleum Geology,* 11(5):545–560. **https://doi.org/10.1016/0264-8172(94)90067-1**

Ford, M., Williams, E.A., Malartre, F., and Popescu, S.-M., 2007. Stratigraphic architecture, sedimentology and structure of the Vouraikos Gilbert-type fan delta, Gulf of Corinth, Greece. *In* Nichols, G., Paola, C., and Williams, E. (Eds.), *Sedimentary Processes, Environments and Basins: A Tribute to Peter Friend.* Jarvis, I. (Series Ed.). Special Publication of the International Association of Sedimentologists, 38:44–90. **https://doi.org/10.1002/9781444304411.ch4**

Ford, M., Rohais, S., Williams, E.A., Bourlange, S., Jousselin, D., Backert, N., and Malartre, F., 2013. Tectono-sedimentary evolution of the western Corinth Rift (central Greece). *Basin Research,* 25(1):3–25. **https://doi.org/10.1111/j.1365-2117.2012.00550.x**

Gawthorpe, R.L., Jackson, C.A.-L., Young, M.J., Sharp, I.R., Moustafa, A.R., and Leppard, C.W., 2003. Normal fault growth, displacement localisation and the evolution of normal fault populations: the Hammam Faraun fault block, Suez Rift, Egypt. *Journal of Structural Geology,* 25(6):883–895. **https://doi.org/10.1016/S0191-8141(02)00088-3**

Higgs, B., 1988. Syn-sedimentary structural controls on basin deformation in the Gulf of Corinth, Greece. *Basin Research,* 1(3):155–165. **https://doi.org/10.1111/j.1365-2117.1988.tb00012.x**

Huismans, R.S., and Beaumont, C., 2007. Roles of lithospheric strain softening and heterogeneity in determining the geometry of rifts and continental margins. *Geological Society Special Publications,* 282(1):111–138. **https://doi.org/10.1144/SP282.6**

Huismans, R., and Beaumont, C., 2011. Depth-dependent extension, two-stage breakup and cratonic underplating at rifted margins. *Nature*, 473(7345):74–78. **http://dx.doi.org/10.1038/nature09988**

Jolivet, L., 2001. A comparison of geodetic and finite strain pattern in the Aegean, geodynamic implications. *Earth and Planetary Science Letters,* 187(1–2):95–104. **https://doi.org/10.1016/S0012-821X(01)00277-1**

Jolivet, L., Brun, J.-P., Gautier, P., Lallament, S., and Patria, M., 1994. 3D-kinematics of extension in the Aegean region from the early Miocene to the present: insights from the ductile crust. *Bulletin de la Société Géologique de France,* 165(3):195–209. **http://bsgf.geoscienceworld.org/content/gssgfbull/165/3/195.full.pdf**

Jolivet, L., Labrousse, L., Agard, P., Lacombe, O., Bailly, V., Lecomte, E., Mouthereau, F., and Mehl, C., 2010. Rifting and shallow-dipping detachments, clues from the Corinth Rift and the Aegean. *Tectonophysics,* 483(3–4):287–304. **https://doi.org/10.1016/j.tecto.2009.11.001**

Lavier, L.L., and Buck, W.R., 2002. Half graben versus large-offset low-angle normal fault: importance of keeping cool during normal faulting. *Journal of Geophysical Research: Solid Earth,* 107(B6):ETG 8-1–ETG 8-13. **https://doi.org/10.1029/2001JB000513**

Lavier, L.L., and Manatschal, G., 2006. A mechanism to thin the continental lithosphere at magma-poor margins. *Nature,* 440(7082):324–328. **https://doi.org/10.1038/nature04608**

Le Pichon, X., and Angelier, J., 1981. Extensional tectonics associated with convergent plate boundaries —the Aegean Sea. *Philosophical Transactions of the Royal Society, A: Mathematical, Physical & Engineering Sciences,* 300(1454):357–372. **https://doi.org/10.1098/rsta.1981.0069**

Leeder, M.R., Collier, R.E.L., Abdul Aziz, L.H., Trout, M., Ferentinos, G., Papatheodorou, G., and Lyberis, E., 2002. Tectono-sedimentary processes along an active marine/lacustrine half-graben margin: Alkyonides Gulf, E. Gulf of Corinth, Greece. *Basin Research,* 14(1):25–41. **https://doi.org/10.1046/j.1365-2117.2002.00164.x**

Leeder, M.R., Mack, G.H., Brasier, A.T., Parrish, R.R., McIntosh, W.C., Andrews, J.E., and Duermeijer, C.E., 2008. Late-Pliocene timing of Corinth (Greece) rift-margin fault migration. *Earth and Planetary Science Letters,* 274(1–2):132–141. **https://doi.org/10.1016/j.epsl.2008.07.006**

Leeder, M.R., Mark, D.F., Gawthorpe, R.L., Kranis, H., Loveless, S., Pedentchouk, N., Skourtsos, E., Turner, J., Andrews, J.E., and Stamatakis, M., 2012. A "Great Deepening": chronology of rift climax, Corinth Rift, Greece. *Geology,* 40(11):999–1002. **https://doi.org/10.1130/G33360.1**

Leeder, M.R., Portman, C., Andrews, J.E., Collier, R.E.L., Finch, E., Gawthorpe, R.L., McNeill, L.C., Pérez-Arlucea, M., and Rowe, P., 2005. Normal faulting and crustal deformation, Alkyonides Gulf and Perachora Peninsula, eastern Gulf of Corinth Rift, Greece. *Journal of the Geological Society,* 162(3):549–561. **https://doi.org/10.1144/0016-764904-075**

Lund, S.P., Schwartz, M., Keigwin, L., and Johnson, T., 2005. Deep-sea sediment records of the Laschamp geomagnetic field excursion (~41,000 calendar years before present). *Journal of Geophysical Research: Solid Earth,* 110(B4):B04101. **http://dx.doi.org/10.1029/2003JB002943**

Lykousis, V., Sakellariou, D., Moretti, I., and Kaberi, H., 2007. Late Quaternary basin evolution of the Gulf of Corinth: sequence stratigraphy, sedimentation, fault-slip and subsidence rates. *Tectonophysics,* 440(1–4):29–51. **https://doi.org/10.1016/j.tecto.2006.11.007**

Manatschal, G., Froitzheim, N., Rubenach, M., and Turrin, B., 2001. The role of detachment faulting in the formation of an ocean-continent transition: insights from the Iberia Abyssal Plain. *In* Wilson, R.C.L., Whitmarsh, R.B., Taylor, B., and Froitzheim, N. (Eds.), *Non-Volcanic Rifting of Continental Margins: A Comparison of Evidence from Land and Sea.* Geological Society Special Publication, 187(1):405–428. **http://dx.doi.org/10.1144/GSL.SP.2001.187.01.20**

McKenzie, D., 1978. Some remarks on the development of sedimentary basins. *Earth and Planetary Science Letters,* 40(1):25–32. **http://dx.doi.org/10.1016/0012-821X(78)90071-7**

McLeod, A.E., Dawers, N.H., and Underhill, J.R., 2000. The propagation and linkage of normal faults: insights from the Strathspey-Brent-Statfjord fault array, northern North Sea. *Basin Research,* 12(3–4):263–284. **https://doi.org/10.1111/j.1365-2117.2000.00124.x**

McNeill, L.C., and Collier, R.E.L., 2004. Uplift and slip rates of the eastern Eliki fault segment, Gulf of Corinth, Greece, inferred from Holocene and Pleistocene terraces. *Journal of the Geological Society,* 161(1):81–92. **https://doi.org/10.1144/0016-764903-029**

McNeill, L.C., Cotterill, C.J., Henstock, T.J., Bull, J.M., Stefatos, A., Collier, R.E.L., Papatheoderou, G., Ferentinos, G., and Hicks, S.E., 2005. Active faulting within the offshore western Gulf of Corinth, Greece: implications for models of continental rift deformation. *Geology,* 33(4):241–244. **https://doi.org/10.1130/G21127.1**

Moretti, I., Lykousis, V., Sakellariou, D., Reynaud, J.-Y., Benziane, B., and Prinzhoffer, A., 2004. Sedimentation and subsidence rate in the Gulf of Corinth: what we learn from the *Marion Dufresne*'s long-piston coring. *Comptes Rendus Geoscience,* 336(4–5):291–299. **https://doi.org/10.1016/j.crte.2003.11.011**

Nixon, C.W., McNeill, L.C., Bull, J.M., Bell, R.E., Gawthorpe, R.L., Henstock, T.J., Christodoulou, D., Ford, M., Taylor, B., Sakellariou, D., Ferentinos, G., Papatheodorou, G., Leeder, M.R., Collier, R.E.L., Goodliffe, A.M., Sachpazi, M., and Kranis, H., 2016. Rapid spatiotemporal variations in rift structure during development of the Corinth Rift, central Greece. *Tectonics,* 35(5):1225–1248. **https://doi.org/10.1002/2015TC004026**

Osmundsen, P.T., and Ebbing, J., 2008. Styles of extension offshore mid-Norway and implications for mechanisms of crustal thinning at passive margins. *Tectonics,* 27(6):TC6016. **https://doi.org/10.1029/2007TC002242**

Reston, T.J., Krawczyk, C.M., and Hoffmann, H.J., 1995. Detachment tectonics during Atlantic rifting: analysis and interpretation of the S reflection, the west Galicia margin. *In* Scrutton, R.A., Stoker, M.S., Shimmield, G.B., and Tudhope, A.W. (Eds.), *The Tectonics, Sedimentation, and Palaeoceanography of the North Atlantic Region.* Geological Society Special Publication, 90:93–109. **http://dx.doi.org/10.1144/GSL.SP.1995.090.01.05**

Rohais, S., Eschard, R., Ford, M., Guillocheau, F., and Moretti, I., 2007. Stratigraphic architecture of the Plio–Pleistocene infill of the Corinth Rift: implications for its structural evolution. *Tectonophysics,* 440(1–4):5–28. **https://doi.org/10.1016/j.tecto.2006.11.006**

Sachpazi, M., Galvé, A., Laigle, M., Hirn, A., Sokos, E., Serpetsidaki, A., Marthelot, J.-M., Pi Alperin, J.M., Zelt, B., and Taylor, B., 2007. Moho topography under central Greece and its compensation by Pn time-terms for the accurate location of hypocenters: the example of the Gulf of Corinth 1995 Aigion earthquake. *Tectonophysics,* 440(1–4):53–65. **https://doi.org/10.1016/j.tecto.2007.01.009**

Sachpazi, M., Clément, C., Laigle, M., Hirn, A., and Roussos, N., 2003. Rift structure, evolution, and earthquakes in the Gulf of Corinth, from reflection seismic images. *Earth and Planetary Science Letters,* 216(3):243–257. **https://doi.org/10.1016/S0012-821X(03)00503-X**

Sakellariou, D., Lykousis, V., Alexandri, S., Kaberi, H., Rousakis, G., Nomikou, P., Georgiou, P., and Ballas, D., 2007. Faulting, seismic-stratigraphic architecture and Late Quaternary evolution of the Gulf of Alkyonides Basin–East Gulf of Corinth, Central Greece. *Basin Research,* 19(2):273–295. **https://doi.org/10.1111/j.1365-2117.2007.00322.x**

Sharp, I.R., Gawthorpe, R.L., Underhill, J.R., and Gupta, S., 2000. Fault-propagation folding in extensional settings: examples of structural style and synrift sedimentary response from the Suez Rift, Sinai, Egypt. *Geological Society of America Bulletin,* 112(12):1877–1899. **https://doi.org/10.1130/0016-7606(2000)112<1877:FPFIES>2.0.CO;2**

Skourtsos, E., and Kranis, H., 2009. Structure and evolution of the western Corinth Rift, through new field data from the northern Peloponnesus. *In* Ring, U., and Wernicke, B. (Eds.), *Extending a Continent: Architecture, Rheology and Heat Budget.* Geological Society Special Publication, 321(1):119–138. **https://doi.org/10.1144/SP321.6**

Stefatos, A., Papatheodorou, G., Ferentinos, G., Leeder, M., and Collier, R., 2002. Seismic reflection imaging of active offshore faults in the Gulf of Corinth, Greece: their seismotectonic significance. *Basin Research,* 14(4):487–502. **https://doi.org/10.1046/j.1365-2117.2002.00176.x**

Stott, L., Poulsen, C., Lund, S., and Thunell, R., 2002. Super ENSO and global climate oscillations at millennial time scales. *Science,* 297(5579):222–226. **http://dx.doi.org/10.1126/science.1071627**

Taylor, B., Weiss, J.R., Goodliffe, A.M., Sachpazi, M., Laigle, M., and Hirn, A., 2011. The structures, stratigraphy and evolution of the Gulf of Corinth Rift, Greece. *Geophysical Journal International,* 185(3):1189–1219. **https://doi.org/10.1111/j.1365-246X.2011.05014.x**

Taylor, S.K., Bull, J.M., Lamarche, G., and Barnes, P.M., 2004. Normal fault growth and linkage in the Whakatane Graben, New Zealand, during the last 1.3 Myr. *Journal of Geophysical Research: Solid Earth,* 109(B2):B02408. **https://doi.org/10.1029/2003JB002412**

Tiberi, C., Lyon-Caen, H., Hatzfeld, D., Achauer, U., Karagianni, E., Kiratzi, A., Louvari, E., Panagiotopoulos, D., Kassaras, I., Kaviris, G., Makropoulos, K., and Papadimitriou, P., 2000. Crustal and upper mantle structure beneath the Corinth Rift (Greece) from a teleseismic tomography study. *Journal of Geophysical Research: Solid Earth,* 105(B12):28159–28171. **https://doi.org/10.1029/2000JB900216**

Tzedakis, P.C., Hooghiemstra, H., and Pälike, H., 2006. The last 1.35 million years at Tenaghi Philippon: revised chronostratigraphy and long-term vegetation trends. *Quaternary Science Reviews,* 25(23–24):3416–3430. **https://doi.org/10.1016/j.quascirev.2006.09.002**

Valet, J.-P., Meynadier, L., and Guyodo, Y., 2005. Geomagnetic dipole strength and reversal rate over the past two million years. *Nature,* 435(7043):802–805. **http://dx.doi.org/10.1038/nature03674**

Whitmarsh, R.B., Manatschal, G., and Minshull, T.A., 2001. Evolution of magma-poor continental margins from rifting to seafloor spreading. *Nature,* 413(6852):150–154. **http://dx.doi.org/10.1038/35093085**

Zelt, B.C., Taylor, B., Sachpazi, M., and Hirn, A., 2005. Crustal velocity and Moho structure beneath the Gulf of Corinth, Greece. *Geophysical Journal International,* 162(1):257–268. **https://doi.org/10.1111/j.1365-246X.2005.02640.x**

Zelt, B.C., Taylor, B., Weiss, J.R., Goodliffe, A.M., Sachpazi, M., and Hirn, A., 2004. Streamer tomography velocity models for the Gulf of Corinth and Gulf of Itea, Greece. *Geophysical Journal International*, 159(1):333–346. **https://doi.org/10.1111/j.1365-246X.2004.02388.x**

Table T1. Location of and information for proposed primary and alternate sites.

Site	Position	Water depth (m)	Penetration (m)	Primary/alternate	Site-specific objectives
COR-01A	38.15840087, 22.69536544 (38°9′30.243N, 22°41′43.316E)	852	750	Primary site	• Core and wireline log seismic Unit 2 (expected late Pleistocene interbedded marine-lacustrine hemipelagic gravity flow deposits) and underlying unconformity to • Determine age, lithology, and paleoenvironment of most recent synrift stratigraphic sequence. • Determine nature and age of regional unconformity and change in age and environment across the unconformity. • Utilize chronostratigraphy to analyze fault and rift development and sediment flux history by core-log-seismic integration.
COR-02A	38.144942, 22.758405 (38°8′41.791N, 22°45′30.258E)	862	750	Primary site	• Core and wireline log seismic Unit 2 (expected late Pleistocene interbedded marine-lacustrine deposits), regional unconformity, and seismic Unit 1 (expected Pliocene–Pleistocene lacustrine-fluvial synrift deposits) to • Determine age, lithology, and paleoenvironment of most recent synrift stratigraphic sequence (seismic Unit 2). • Determine nature and age of regional unconformity and change in age and environment across the unconformity. • Establish age and paleoenvironment of seismic Unit 1 for integration with onshore synrift stratigraphy and rift evolution timing along the rift axis (by comparison with Site COR-04B). • Utilize chronostratigraphy of complete section to analyze fault and rift development and sediment flux history by core-log-seismic integration.
COR-03B	38.11740647, 23.10622823 (38°7′2.663N, 23°6′22.422E)	347	727	Alternate site	• Core and wireline log seismic Unit 2 (expected late Pleistocene interbedded marine-lacustrine deposits), regional unconformity, and seismic Unit 1 (expected Pliocene–Pleistocene lacustrine-fluvial synrift deposits) to • Determine age, lithology, and paleoenvironment of most recent synrift stratigraphic sequence (seismic Unit 2). • Determine nature and age of regional unconformity and change in age and environment across the unconformity. • Establish age and paleoenvironment of seismic Unit 1 for integration with onshore synrift stratigraphy and rift evolution timing along the rift axis (by comparison with Site COR-02A). • Utilize chronostratigraphy of complete section to analyze fault and rift development and sediment flux history by core-log-seismic integration.
COR-04B	38.12008304, 23.08627505 (38°7′12.299N, 23°5′10.590E)	365	479	Primary site	• Core and wireline log seismic Unit 2 (expected late Pleistocene interbedded marine-lacustrine deposits), regional unconformity, and seismic Unit 1 (expected Pliocene–Pleistocene lacustrine-fluvial synrift deposits) to • Determine age, lithology, and paleoenvironment of most recent synrift stratigraphic sequence (seismic Unit 2). • Determine nature and age of regional unconformity and change in age and environment across the unconformity. • Establish age and paleoenvironment of seismic Unit 1 for integration with onshore synrift stratigraphy and rift evolution timing along the rift axis (by comparison with Site COR-02A). • Utilize chronostratigraphy of complete section to analyze fault and rift development and sediment flux history by core-log-seismic integration.
COR-05B	38.28004101, 22.41106702 (38°16′48.148N, 22°24′39.841E)	592	750	Alternate site	• Core and wireline log seismic Unit 2 (expected late Pleistocene interbedded marine-lacustrine deposits), regional unconformity, and seismic Unit 1 (expected Pliocene–Pleistocene lacustrine-fluvial synrift deposits) to • Determine age, lithology, and paleoenvironment of most recent synrift stratigraphic sequence (seismic Unit 2). • Determine nature and age of regional unconformity and change in age and environment across the unconformity. • Establish age and paleoenvironment of seismic Unit 1 for integration with onshore synrift stratigraphy and rift evolution timing along the rift axis (by comparison with Site COR-03). • Utilize chronostratigraphy of complete section to analyze fault and rift development and sediment flux history by core-log-seismic integration.
COR-06A	38.17666707, 22.71827271 (38°10′36.001N, 22°43′5.782E)	861	750	Alternate site	• Core and wireline log seismic unit 2 (SU2: expected Late Pleistocene interbedded marine-lacustrine hemipelagic-gravity flow deposits), and underlying unconformity to • Determine age, lithology, and paleoenvironment of most recent synrift stratigraphic sequence. • Determine nature and age of regional unconformity and change in age and environment across the unconformity. • Utilize chronostratigraphy to analyze fault and rift development and sediment flux history by core-log-seismic integration.

Table T2. Geophysical site survey data used to implement this project and fully integrated digitally as part of the UK IODP-NERC Virtual Site Survey (VSS) project with results published in Nixon et al. (2016) (see Figures F1 and F4–F10). * = data sets publicly available at the time of publication.

Source	Data type	Rift distribution
Seismic reflection		
University of Hawaii*	MCS, deep penetrating, digital (e.g., Figures F6, F7D)	Throughout
University of Patras	Single channel, high resolution, scanned analog	Throughout
HCMR	Single channel, high resolution, scanned analog (e.g., Figure F9B, F9C)	Throughout
HCMR	Single channel, high resolution, digital	Western gulf
Southampton/Patras/Leeds*	Multichannel sparker, high resolution, digital (e.g., Figure F7D)	Western gulf
Leeds/UEA/Patras	Single channel sparker, high resolution, scanned analog	Throughout
DEP-Hellenic Petroleum and SEIS-GREECE	Multichannel, deep penetrating, digital	Central gulf
Multibeam		
Southampton*	Reson Seabat 8160, 50 kHz	Western gulf
HCMR	Seabeam 2120, 20 kHz (e.g., Figure F1)	Throughout
University of Hawaii*	Hydrosweep DS2, 15 kHz	Throughout

Table T3. Summary of science party and operator (ESO) personnel, Expedition 381.

	Science party	
ESO (16)	Offshore science team (9)	Expedition scientists
1 ESO Operations Manager 2 ESO Expedition Project Managers (EPMs) 1 ESO Outreach Manager/EPM 2 ESO Curators 1 ESO geochemist 1 ESO Petrophysics Staff Scientist 1 ESO petrophysicist 2 ESO Data Manager 3 ESO Drilling Coordinators 2 logging contractors	2 Co-Chief Scientists 2 sedimentologists 2 paleontologists 1 Physical Properties Specialist 2 geochemists	Offshore and onshore science party members EPM Petrophysics Staff Scientist
Offshore team total: 25		

Figure F1. Overview map of Corinth rift with primary rift-related faults (both active and currently inactive), multibeam bathymetry of the gulf, and proposed drill sites. Fault traces are derived as follows. Offshore: Nixon et al. (2016) building on Bell et al. (2009); Taylor et al. (2011). Onshore: Ford et al. (2007, 2013); Leeder et al. (2012); Skourtsos and Kranis (2009). Inset: tectonic setting of the Corinth rift within the Aegean region, Eastern Mediterranean.

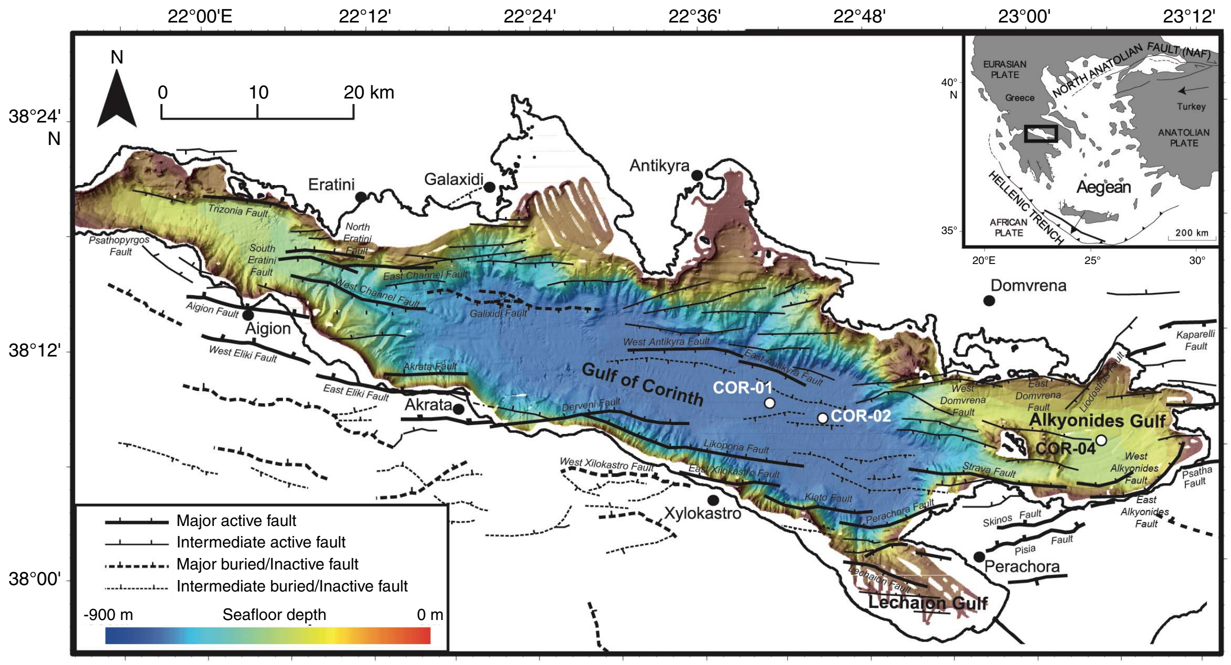

Figure F2. Onshore geology map including distribution of basement units (after Skourtsos and Kranis, 2009) and Pliocene–Quaternary synrift sequences. The northwest–southeast fabric of the Hellenide orogenic belt is also clear in the western half. Dashed line = approximate eastern margin of Pindos units.

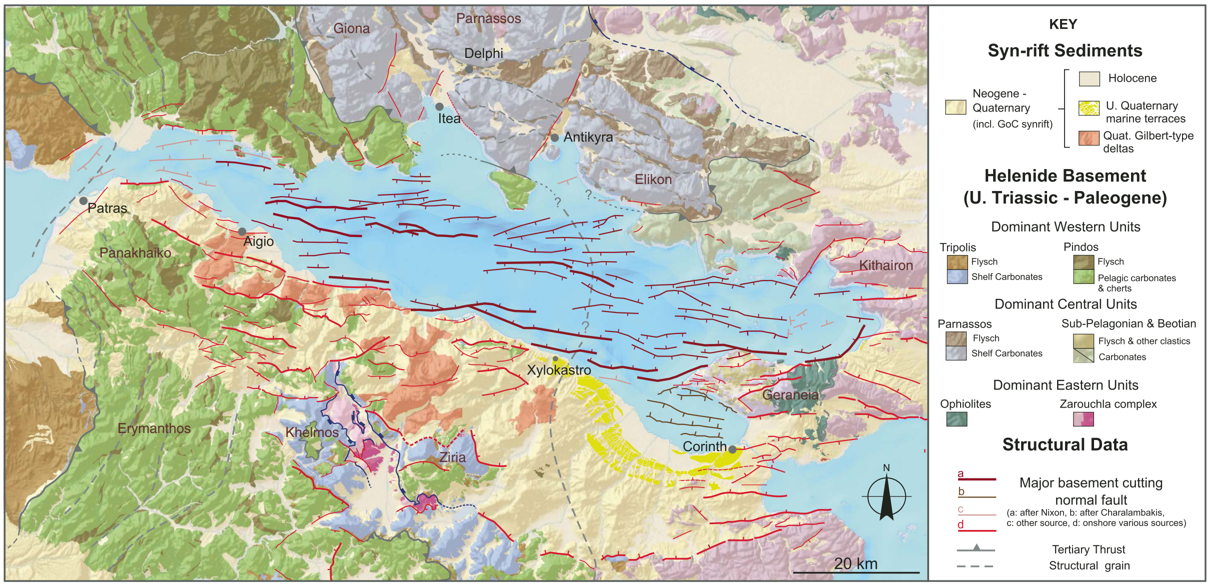

Figure F3. Cartoon demonstrating three proposed rift phases of the Corinth rift system and currently resolved distribution of the rift basins for each phase (after Higgs, 1988) with regional fault map overlain (Nixon et al., 2016) (Figure F1). (Courtesy of D. Sakellariou and V. Lykousis.)

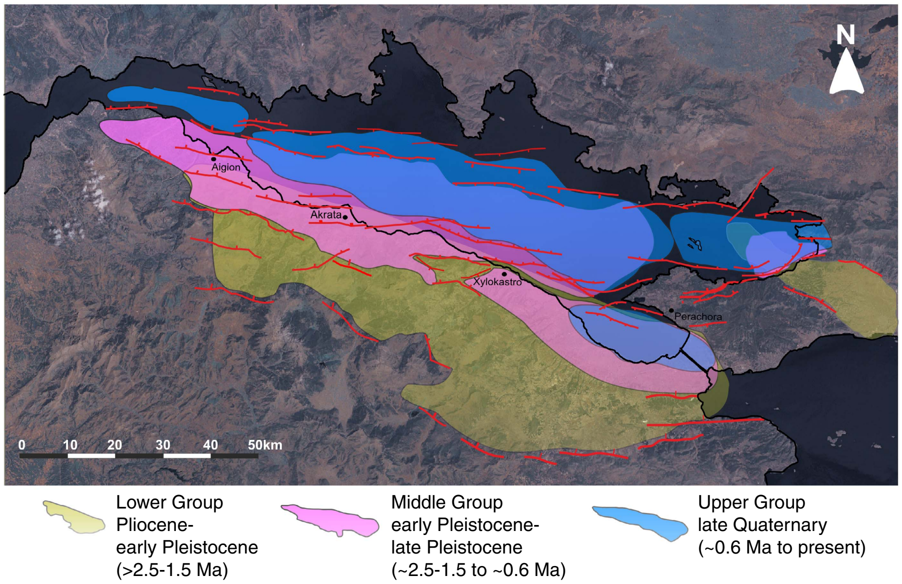

Figure F4. Isochore maps for synrift sequence offshore showing the two primary units separated by a regional unconformity (Nixon et al., 2016; Bell et al., 2009; Taylor et al., 2011). A. Seismic Unit 1 (preregional unconformity, likely equivalent to onshore Middle Group, and estimated age of ≥ ~0.6 Ma). B. Seismic Unit 2 (postregional unconformity, likely equivalent to onshore Upper Group, estimated age of ≤ ~0.6 Ma). Faults represent those dominantly active during the time period shown. (Continued on next page.)

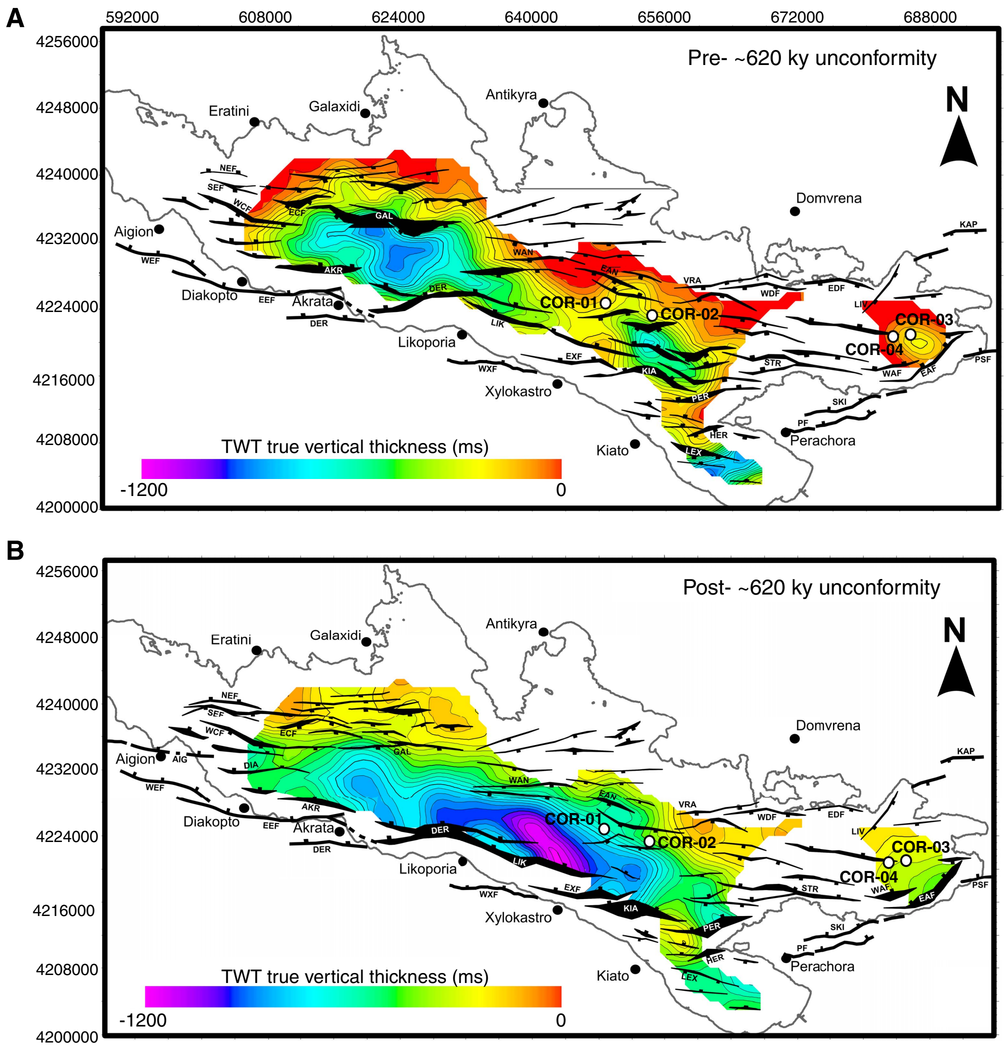

Figure F4 (continued). C–E. Isochore maps for three time intervals within seismic Unit 2 (the youngest synrift package). Fault polygons/traces = heave of the lower horizon of the interval shown. (From Nixon et al., 2016.)

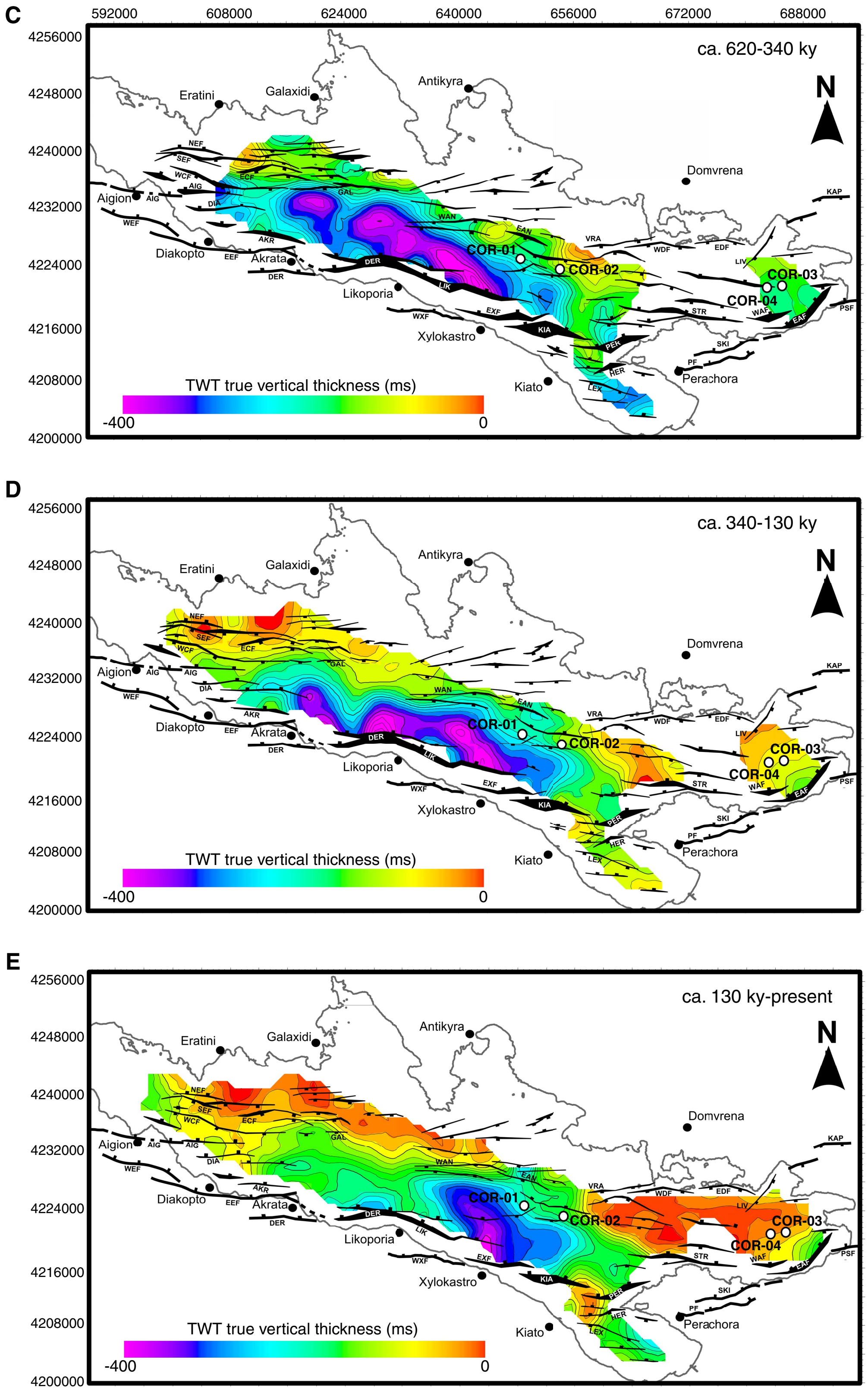

Figure F5. Proposed integrated and reconciled chronology for the seismic stratigraphy of the synrift sequence preserved within the Gulf of Corinth, the currently active rift zone. Based on a sequence stratigraphic interpretation and compiled as part of the VSS integration project (Nixon et al., 2016; after Sachpazi et al., 2003; Bell et al., 2008, 2009; Taylor et al., 2011). A. The unit interpretation is shown for a typical *Ewing* MCS seismic profile with proposed correlations to the eustatic sea level curve (Bintanja and van de Wal, 2008) based on identification of low- and high-amplitude packages thought to represent individual ~100 ky cycles. B. Close-up of boxed area in A showing details of the seismic stratigraphy and horizon age interpretation (left) and amplitude volume attribute applied to the data (right) highlighting the contrasting seismic character of the high-amplitude (predicted marine highstand) and low-amplitude (predicted lacustrine lowstand) packages.

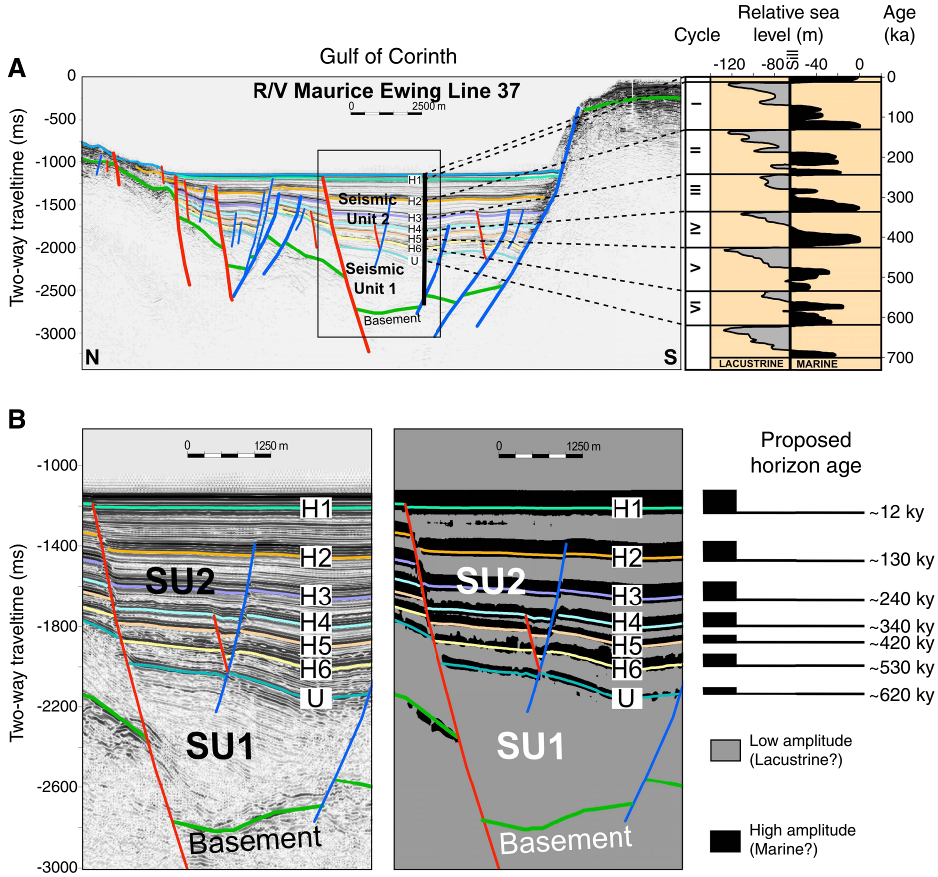

Figure F6. Close-up images of seismic profiles for the three primary sites (COR-01A, COR-02A, and COR-04B) with the unconformity separating seismic Units 1 and 2 clearly visible.

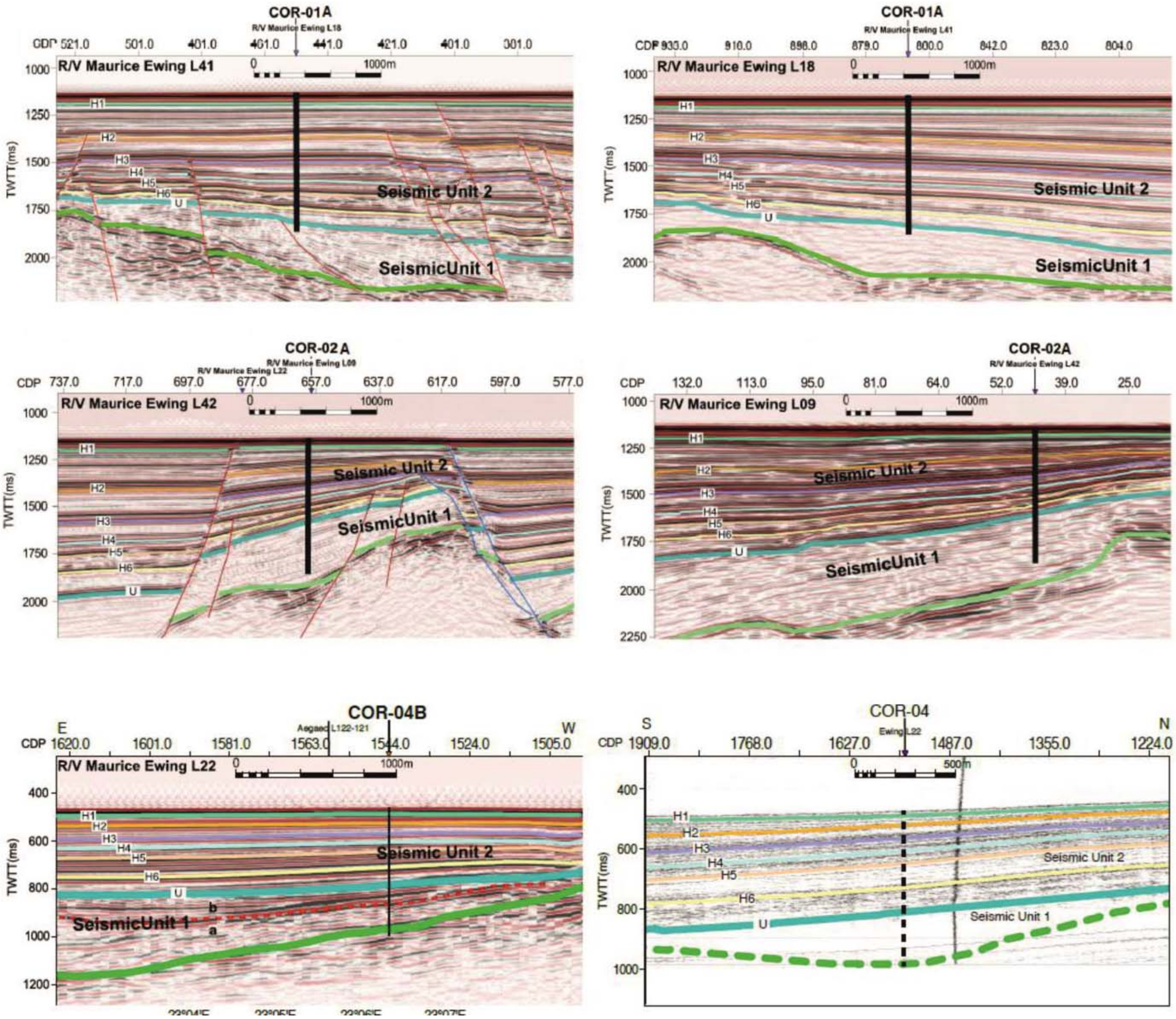

Figure F7. Close-up images of seismic profiles for the three alternate sites (COR-03B, COR-05B, and COR-06A) with the unconformity separating seismic Units 1 and 2 clearly visible.

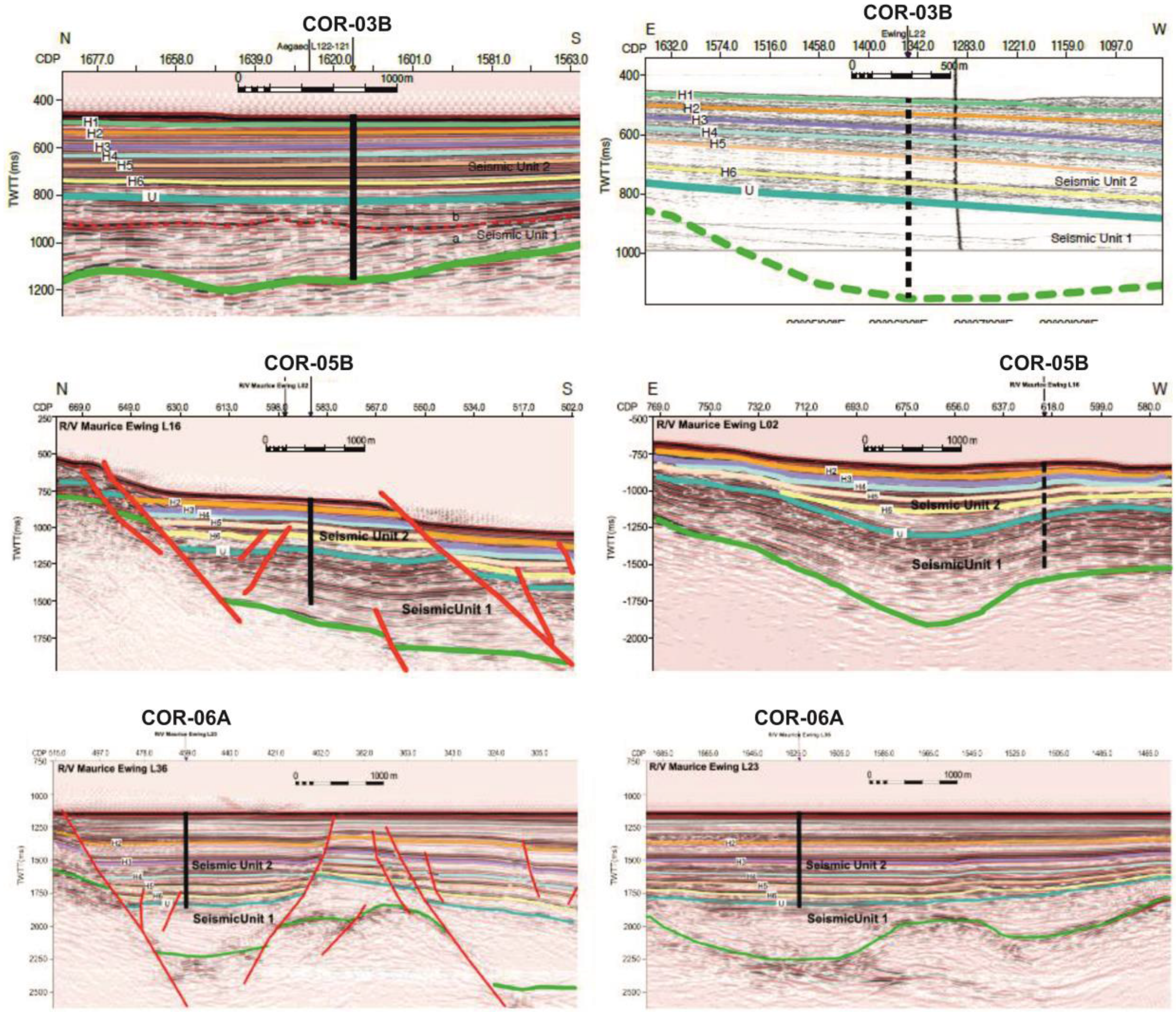

Figure F8. A, B. Example MCS seismic profile (*Ewing* Line 41) demonstrating the potential spatial resolution achievable and hence likely temporal resolution (from current proposed chronology from sequence stratigraphic). C. Zoomed section of Profile 41 where seismic Unit 2 is expanded relative to the borehole site. Proposed Site COR-01A samples seismic Unit 2 in the central basin but through correlation to more expanded parts of the section further south along the profile (C: location of zoomed panel), an even greater resolution is possible (i.e., larger number of correlatable reflectors). D. Equivalent section of uppermost seismic Unit 2 from high-resolution sparker data elsewhere in the central basin (e.g., Bell et al., 2008), showing the even greater spatial and temporal resolution achievable where high-resolution data sets are available. For C and D, approximate ages of horizons are those proposed from the current sequence stratigraphic interpretation but unresolved as yet by drilling (Figure **F5**).

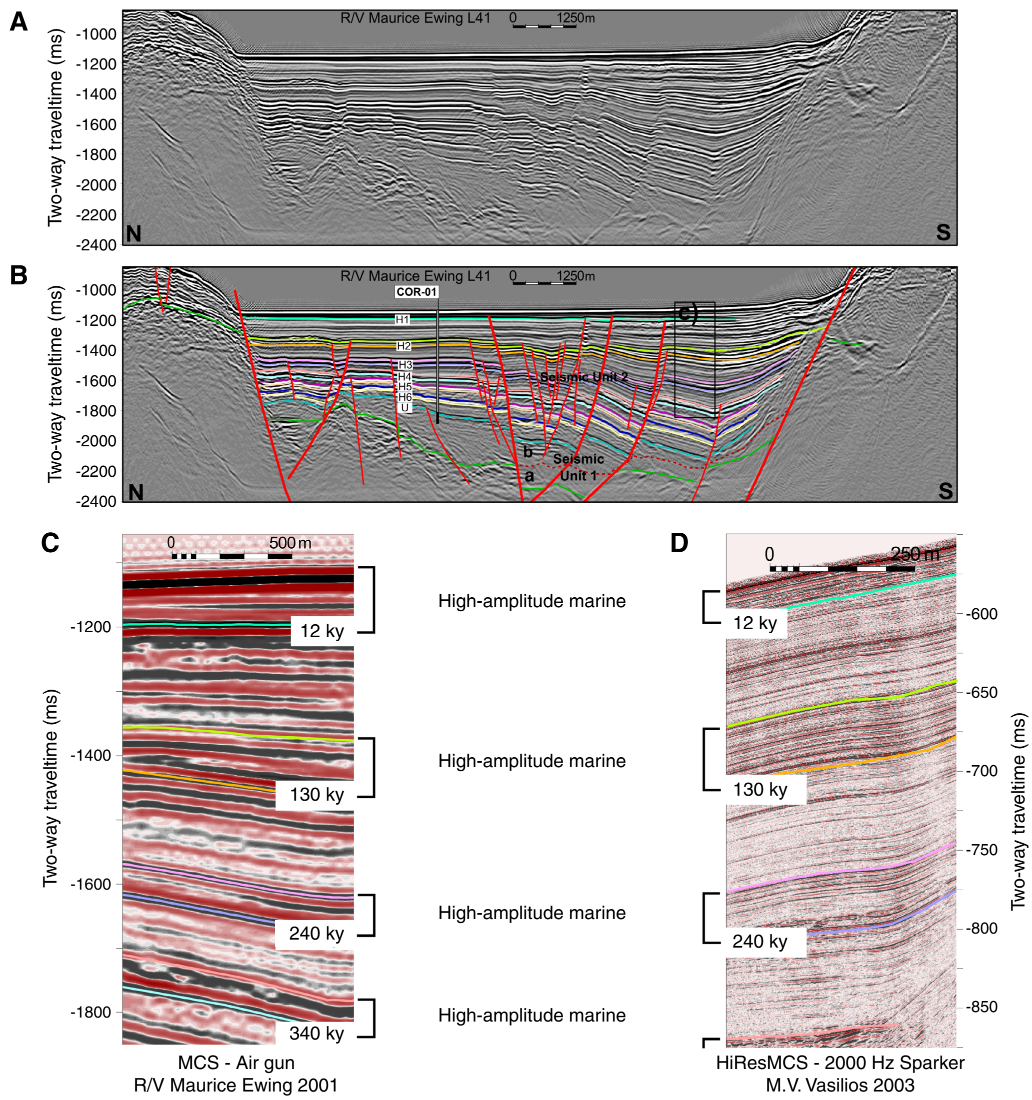

Figure F9. Map of data available to this project, including seismic data incorporated within the data integration and correlation exercise and published in Nixon et al. (2016), and showing the extent and density of existing data and the range of data resolutions. Seismic profile spacing and hence horizontal resolution is hundreds of meters to ~2 km for the majority of the active rift. Example publications showing different seismic data sets: Ewing, 2001 (Zelt et al., 2004; Taylor et al., 2011); Vasilios multichannel, 2003 (McNeill et al., 2005; Bell et al., 2008, 2009); Aegeao (Lykousis et al., 2007; Sakellariou et al., 2007); Vasilios single channel, 1996 (Leeder et al., 2002, 2005); Shackleton, 1982 (Stefatos et al., 2002; Higgs, 1988); high-resolution pinger/sparker (Stefatos et al., 2002; Charalampakis et al., 2014). Locations of existing piston and gravity cores are also shown (red dot = HCMR cores partly unpublished; red star = Moretti et al. [2004], blue dot = Collier et al. [2000]).

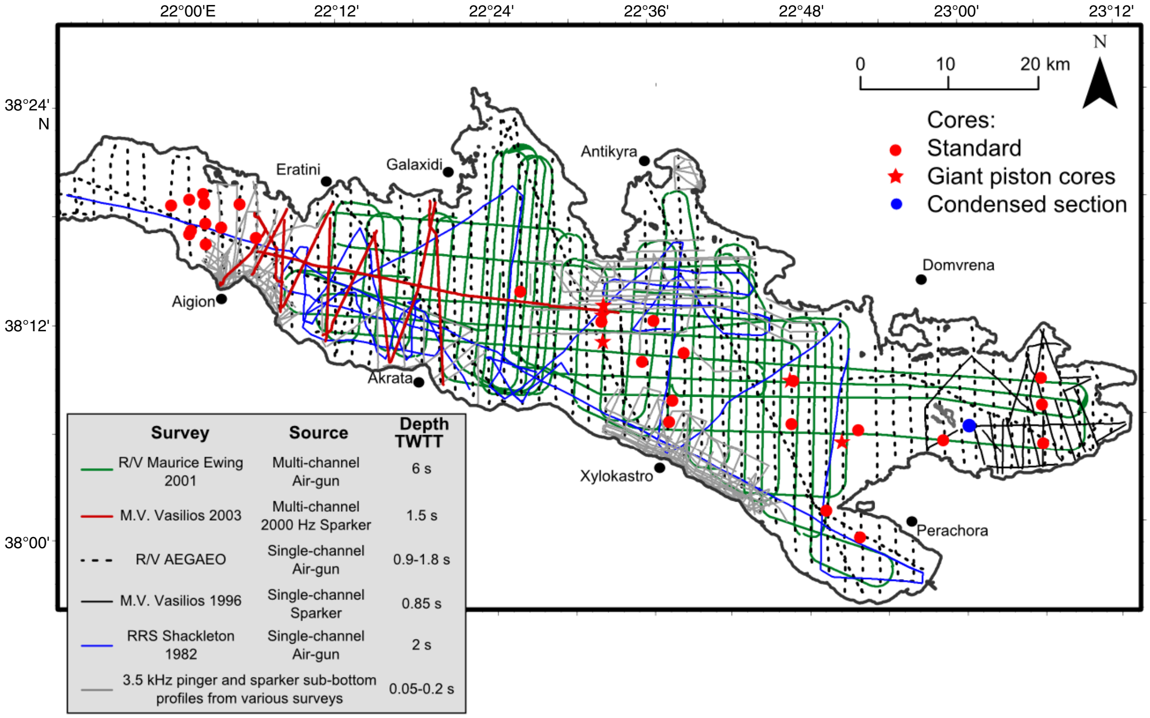

Figure F10. Seismic profile of proposed drill Site COR-01A targeting the complete seismic Unit 2 sequence and regional unconformity (U). Proposed borehole drilling depth also shown; black line marks estimated depth of a 750 m borehole using a realistic velocity model derived from multiple seismic velocity models. Gray line indicates estimated depth of a 750 m borehole with a conservative velocity model. We expect the velocity model applied (nonconservative) to be realistic, and this expectation informs the site details.

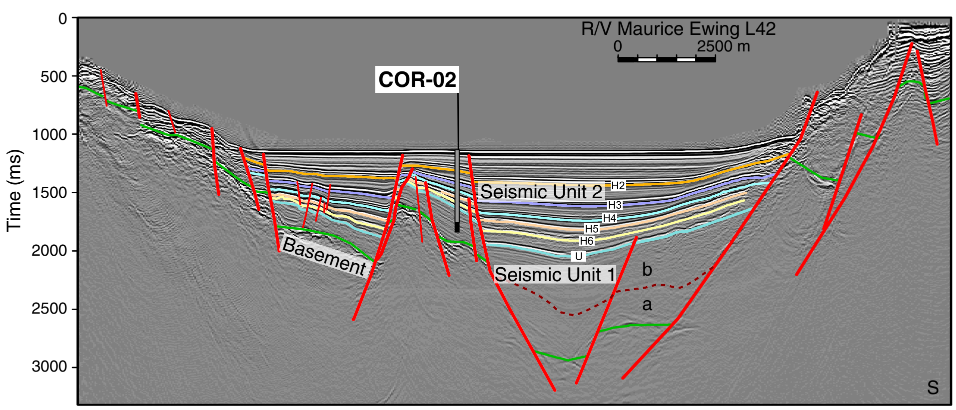

Figure F11. Seismic profile of proposed drill Site COR-02A on a topographic high and relatively condensed section targeting seismic Unit 2, the regional unconformity (U) and the upper 1/3 to 1/2 of seismic Unit 1 (expected seismic Subunit 1b). Proposed borehole drilling depth also shown; black line marks estimated depth of a 750 m borehole using a realistic velocity model derived from multiple seismic velocity models. Gray line indicates estimated depth of a 750 m borehole using a more conservative velocity model. We expect the velocity model applied (nonconservative) to be realistic, and this expectation informs the site details.

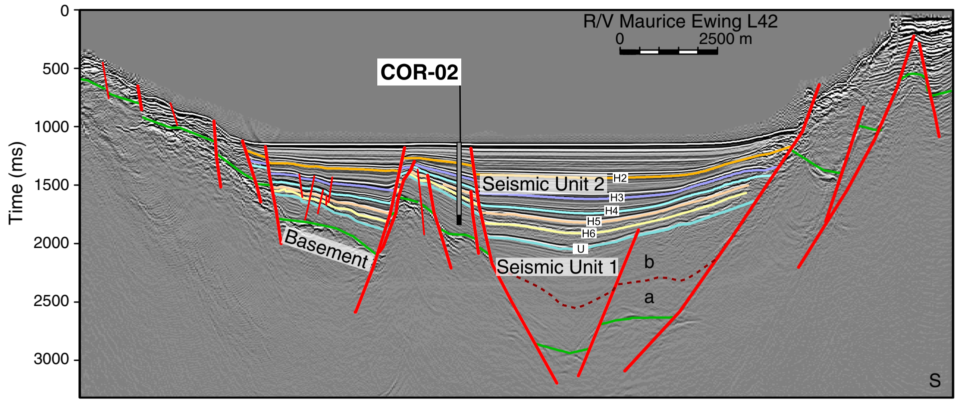

Figure F12. Seismic profiles of proposed drill Sites COR-04 (primary) and COR-03 (alternate) targeting seismic Unit 2, the regional unconformity, and the underlying seismic Unit 1. At Site COR-04B, basement and the overlying deep seismic Unit 1 sediments can be reached. The (A) along-rift profile and (B, C) across-rift crossing profiles for Sites COR-03 and COR-04, respectively, show the rift structure context of each site. Proposed borehole drilling depths for the boreholes are also shown. For Site COR-04B (alternate), drilling is proposed to basement at ~470 m (depth derived from the realistic velocity model) plus 10 m of basement (gray line).