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RADIOCARBON DATING OF THE MAJOR SETTLEMENT AT SKARKOS (IOS ISLAND, CYCLADES) AND INFERENCES FOR THE EARLY CYCLADIC CHRONOLOGY

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ABSTRACT. We have radiocarbon-dated the main settlement of Skarkos (Skarkos II) on the Cycladic island of Ios, using a set of animal bone samples. The site of Skarkos stands on a hill in a coastal plain, mid-way down the western side of Ios island and about 1 km from the island’s harbour. It is the first time this important settlement with a wealth of finds and an extraordinary building system with two-storey houses is dated in absolute terms complementing the chronology of the Cycladic EBA II period. The radiocarbon determinations show that the major phase of the settlement came to an end between circa 2550 and circa 2500 BC. The dates also confirm the archaeological evidence that the main occupation period is dated archaeologically to the EC II period (Keros-Syros culture). Furthermore, in order to embed the new Skarkos dates within the overall Cycladic chronology and define better the end of the EC II phase, we treated the Skarkos dates together with published dates from other Cycladic sites using Bayesian analysis considering two different models.

KEYWORDS: Cyclades chronology, Early Bronze Age, Ios Island, radiocarbon dating, Skarkos.

INTRODUCTION: THE CYCLADIC CONTEXT

In the Early Bronze Age (EBA) of the Aegean (third millennium BC) an extended network of connections was developed (Renfrew 1972; Barber 1987; Broodbank 2000). The Cycladic islands (Figure 1), a Polynesia at the heart of the Aegean Sea, played an important role in those interactions, which reached their peak in the Early Cycladic (EC) II period (early EBA II), the time of the Keros-Syros culture. This situation is demonstrated first by the Cycladic customs and artifacts, mainly marble figurines and marble fine vessels, which were detected at many Aegean sites of that period (Stampolidis and Sotirakopoulou 2018; Marthari et al. 2019); second by images of large longboats for long voyages and raids dated also from the same period, which are depicted both on Cycladic ceramic “frying pans” from the Chalandriani cemetery on Syros (Coleman 1985; Broodbank 1989; Wedde 2000; Marthari 2017b) and on the rock at the site of Vathy on Astypalaea (Vlachopoulos 2017).

Nevertheless, until the 1970s, our knowledge was limited to only certain aspects of the culture developed during the EC II period, since very little was known about the settlements. The few identified examples were either poorly preserved, primarily since later habitation destroyed them to a large extent, or had been excavated only to a limited degree. The available evidence came mainly from the site Dhaskalio Kavos on Keros island and from cemeteries such as the Chalandriani cemetery on Syros, even though both had been partially looted. This was the reason why Colin Renfrew named the culture that developed during that period the Keros-Syros culture (Renfrew 1972).

Over the years, some more EC II domestic sites were located and partially excavated. However, the level of our knowledge about the habitation and society of that period would not have changed significantly if the major settlement at Skarkos on Ios (Figure 2) had not been identified and extensively excavated. The exceptionally well-preserved site at Skarkos

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Figure 1 Map of the Cycladic islands, Greece, showing Skarkos and other domestic Early Cycladic sites.



Figure 2 Map of Ios showing the site of Skarkos.

discovered by Marisa Marthari in the mid-1980s brings a real balance to our knowledge of the most important developmental phase of the Cycladic EBA. It is a large, thriving site, demonstrating that during the EC II period the settlement's urban and architectural forms were quite sophisticated, the use of stamp seals common, and specialized craft production very well-developed. Those features give a more complete explanation of the potential of the Cycladic communities for large-scale interactions in the time of the Keros-Syros culture, which could now be more properly termed the Ios-Keros-Syros culture.



Figure 3 Aerial view of the hill of Skarkos, Skarkos II settlement, and the harbor of Ios, seen from the northeast.

THE SITE OF SKARKOS AND ITS RELATIVE CHRONOLOGY

The site of Skarkos stands on a hill in a coastal plain, mid-way down the western side of the Cycladic Island of Ios and about 1 km from the island's harbour, one of the largest natural harbours in the Cyclades (Figure 3). It was excavated first to a limited extent from 1986 to 1997 (Marthari 1997). The excavations were expanded considerably within the framework of two European Union-funded projects for the site's conservation and promotion in 2004–2009 and 2011–2014 under Marthari's direction bringing to light an Aegean prehistoric site of special importance (Marthari 2018).

The site, as shown by the excavations, ranks among the notable multi-period Bronze Age sites in the Cyclades. Of particular importance is the large EC II settlement, which surmounts the hill of Skarkos. The buildings of the settlement, which are two-storeyed and most of them still stand to the height of the upper storey, cover the entire hill (Figure 4). Almost half of that settlement has come to light by excavation to date. The urban plan and the architecture can be followed over a large and continuous excavated area and do not need to be deduced from building remains exposed in small trenches. This enables us to understand the layout and aspect of settlements in the Cyclades during the period when the EC world was enjoying its heyday.

Numerous well-preserved objects were excavated inside the rooms of the buildings, usually where they had been left when the settlement was abandoned. As discussed elsewhere, the pottery (Figures 5–6) (Marthari 2008), as well as the marble figurines (Figures 7–8) and vessels (Figures 9–10) (Marthari 2017a), leave no doubt that the main phase Skarkos, termed *Skarkos II* (Marthari 2017a), should be assigned to the early EBA II (EC II), the time of the Keros-Syros culture. The Skarkos phase II pottery assemblage presents strong stylistic



Figure 4 Skarkos II. Building Alpha seen from the west.

similarities in certain wares with other EC II domestic pottery assemblages, such as the Ayia Irini period II, Phylakopi phase A2 (Marthari 2008; Wilson 2013) and Dhaskalio phase A (Marthari 2017a, 2018; Sotirakopoulou 2016). The wares are fine (*Urfirnis*, mottled and dark-on-light painted), semi-fine (dark-on-light painted broad-streak collared jars), and coarse (talc ware), most imported at each of the four settlement sites. The Markiani period III pottery assemblage (Birtacha 2006), which essentially comes from a single deposit, also shows strong similarities with that from Skarkos II in terms of coarse pottery. Almost all types of coarse and, as a rule, local pottery from Markiani III (Birtacha 2006; Vaughan 2006) find parallels in the Skarkos II local pottery. However, it should be noted that Markiani III does not include imported wares, and indeed imported fine and/or patterned painted wares are those that primarily help in chronological synchronisms.

A habitation period earlier than the main one, termed *Skarkos I* (Marthari 2017a), has been recently identified at Skarkos. There are a few buildings dating from that period located only on the top of the hill, which must have been sealed for most of their part during the main occupation period (Skarkos II). The pottery assemblage and the marble vessels



Figure 5 Skarkos II. A selection of eating, drinking, serving, and cooking ceramic vessels.



Figure 6 Skarkos II. Ceramic amphora with grooved handles.

coming from that earlier nucleus of the settlement are representative of the EBA I (EC I) (Marthari 2017a).

There is not a single example of the diagnostic Anatolian pottery types of the Kastri group to be found on Skarkos hill. A few sherds of the EC III (Phylakopi I culture) and several of the early Middle Cycladic period are included in the surface finds, but so far none have been found in association with building remains. The late Middle Cycladic and early Late Cycladic, namely



Figure 7 Skarkos II. Marble anthropomorphic figurines of the Chalandriani variety.



Figure 8 Skarkos II. Marble schematic figurines of the Apeiranthos type.



Figure 9 Marble footed bowl.



Figure 10 Marble horizontal lug bowl.

the era of Minoan influence in the Cyclades, are represented at Skarkos by a cemetery revealed to the northeast of the hill and a deposit of a domestic character excavated to the south. Both the cemetery and the domestic deposit lie above the Skarkos II settlement but caused little disturbance to it. Finally, the Mycenaean sherds retrieved from the surface finds as well as the remains of a chamber tomb on the southern foothills of Skarkos hill testify to the continuation of at least burial use in the Mycenaean period (Marthari 2009).

THE EC II SKARKOS SETTLEMENT (SKARKOS II)

The settlement plan and architecture of Skarkos II were complicated (Marthari 2018). Rectangular buildings were arranged in concentric zones, along streets, and around small squares. The settlement grew larger with the construction of new buildings, which were added

to the older ones. The form and plan of the buildings underwent continuous development while respecting the community's unwritten codes.

The settlement is not protected by a separate fortification wall; the entrance to the settlement's public areas, however, was through gates. The site was further protected at some later point within the early EBA II period by sealing almost all the openings of its outer zone. In this way, the exterior walls of the outer zone buildings were transformed into a single perimeter wall, for demarcating and, obviously, protecting the site. The settlement had a quite complex drainage network. Both the protection system and the drainage system of the settlement indicate a high level of community planning and community work.

The houses differ in size and complexity. Some are small and of a simple layout, while others are larger, two-storeyed (Figure 4), and more complex in arrangement. This indicates differentiations in the economic circumstances and the social status of the "families" residing in them. The larger houses have 8–12 rooms in total. In addition to the ground floor rooms, some of the upper-storey rooms were used for storing large quantities of provisions. An outside stone-built staircase provides access to the upper storey in each of the two-storeyed buildings. However, it is possible that there were also interior wooden staircases leading from the ground floor to the upper storey. Cupboards, in the form of niches in the wall, are quite common, and there is evidence that they had wooden doors.

Some open spaces were used not only for circulatory purposes but for gatherings, combined with the cooking and communal consumption of food and drink. Individuals or "family" groups who participated in these feasts had the opportunity to display imported fine tableware, in this way expressing their special status.

Skarkos II developed agricultural, craft, and trading activities (Marthari 2008, 2017a). Craft specialization is particularly evident in the settlement. Indeed, the most recent excavations at Skarkos provided valuable data on the craft activities of the EC communities recovering two marble workshops for the first time in the Cyclades. In addition, a building was revealed, the artifacts of which leave no doubt about the practice of metalworking at the EC settlements from so early on. The evidence demonstrates that Skarkos II was a major marble-working centre. Luxury and/or prestige objects, such as marble figurines (Figures 7–8) and fine vessels (Figures 9–10), were produced there in considerable numbers and circulated in the regional exchange networks in which Skarkos II participated.

The first marble workshop was revealed in the so-called *Building of the Figurines*, in the southeastern quarter of the settlement. Sixteen figurines were found there, whereas other buildings usually yielded only one to four figurines. Furthermore, certain special finds and concentrations of finds indicate that one or more craftsmen may have been working there (on marble and possibly on a variety of other materials). The artifacts include among others an unfinished marble figurine, an unfinished marble bowl, fragments of other fine marble vessels, marble flakes, emery tools, tools and raw pieces of pumice, abundant obsidian blades, lumps of mineral red pigment, and one bone tube used as pigment container.

A second marble workshop settled in the upper storey room of *Building Kappa*, in the north part of the settlement, was connected to the manufacture mainly of marble vessels. The artifacts found in the room are indicative of various phases of marble processing. Most of them were recovered in situ on the upper floor and only a few had fallen into the lower ground floor. They comprise a large piece of raw white marble with traces of some initial processing, partly worked

vessels including two bowls and a small palette, a huge palette in the process of manufacture, a large rectangular flat piece of marble used as a working surface, andesite, pumice, scoria and marble tools, and obsidian blades.

It is particularly important that in *Building Beta-Beta*, a narrow structure with two rooms next to *Building Kappa*, a number of artifacts were recovered showing the practice of metalworking including a portable hearth with copper residues on its inner surface and two clay *tuyères*. They could either be indicative of metallurgical activities in situ or could also represent the storage of these artifacts for use elsewhere. Therefore, Skarkos is added to the very few EBA domestic sites, where metalworking was practised already from the EBA.

Despite the absence of sealings, Skarkos's rich evidence argues for a beyond-decorative use of seals in the Cyclades, beginning in the early EBA II. The most stimulating finds from Skarkos include seals, cubic seal-impressed terracotta objects in large numbers, and seal-impressed pottery, all from excellently documented contexts. The excavation data leaves no doubt that there existed sealing practices possibly for indicating ownership of the containers, the nature and/or properties of the commodities stored in them, or the origin of the containers. The stamping practices from Skarkos II and the variety and complexity of the seal motifs all show that intensive use was made of seals in EC II communities (Marthari 2004, 2018).

The importance of the site with its rich cultural activity in the EC II deserves an accurate absolute chronology with radiocarbon dating, which is the aim of this article. Furthermore, the entire series of complete ceramic vessels, as well as marble figurines and fine vessels that were uncovered at EC II Skarkos, allow for a more precise relative chronology of the period. This facilitates the treatment of radiocarbon dates in combination with other sites of the same and also preceding and succeeding periods in order to improve the precision of the Skarkos II dating. In addition, this would allow placing the settlement's chronology within the global absolute Cycladic time framework refining in this way the overall precision for the chronology of the heyday of the EC period and of the Aegean EBA.

SAMPLES AND THEIR STRATIGRAPHY

Apart from a small nucleus near the top of the hill, where there are remains of the Skarkos I period, as mentioned above, the rest of the excavated area that spreads out on the eastern, northern, and southern slopes of the hill, is covered by remains of the Skarkos II period settlement. Radiocarbon samples from deposits of the Skarkos I period are not included in the present article since the remains of this early period had not yet been discovered when this dating work had been practically completed.

Natural bedrock was encountered directly beneath the walls and floors of the Skarkos II period buildings in the aforementioned large area with no remains from an earlier building phase. However, a temporal depth for the EC II settlement can be inferred a) from the reduction of the original area of open spaces due to the addition of new buildings next to old ones and extensions of existing buildings, and b) the sealing of most of the gates of the settlement's outer zone at some point in time. These architectural changes are not reflected in the pottery.

The stratigraphy on the eastern, northern, and southern slopes of the hill is as follows (Marthari 2017a): The *Surface Level (Level 1)* exceeds 0.20 m in thickness and is disturbed. Just below this level, walls of the Skarkos II period buildings were uncovered along with the *Destruction Level (Level 2)* of the settlement; mostly undisturbed. The thickness of this level that is

determined by the height of the surviving buildings varies from 0.60 m to 3.0 or 4.0 m. A thick undisturbed *Ashy Layer (Level 3)*, 0.20–0.60 m thick, was found spread out and levelled over the entire area of some open spaces and on the floors of several rooms on the ground floor of the buildings. In most of these spaces, hearths were found. The ashy layers comprised all manner of discarded waste, such as fragments of ceramic eating and drinking vessels including *Urfirnis* sauceboats, animal bones, shells, broken obsidian blades and small finds. It seems clear that the spaces under consideration, aside from other uses, served as places for holding of communal meals during the life of the settlement. Both the destruction level and ashy layers are assigned to an EC II horizon as demonstrated by the pottery.

The choice of radiocarbon samples was determined so as to obtain absolute dates for Skarkos II (the main phase of Skarkos). Nine well-stratified samples of bone were chosen from Skarkos II levels, all of which contain diagnostic EC II pottery, marble figurines and vessels, and other artifacts. Six of the samples come from destruction debris layers, and three from ashy layers (Table 1).

EXPERIMENTAL TECHNIQUES

The samples were processed at the radiocarbon Unit of the Laboratory of Archaeometry, NCSR “Demokritos” which uses the Gas Proportional Counting technique (GPC). The bones were broken into approximately equal size pieces, roughly 2 cm long. The spongy bone and any encrustations were removed with a lancet. The samples were then washed with deionised water and put in an ultrasonic bath to remove soil or dirt precipitations. This was followed by chemical treatment (Acid-Base-Acid) to extract the collagen and gelatinize it and then combustion to turn the samples into CO₂. For the full treatment and measurement protocols used in the Laboratory, see Maniatis et al. (2016). After the first treatment and combustion it was realised that four of the bone samples were not suitable for dating; either they did not produce enough collagen or the collagen was of poor quality not giving an adequate % of carbon, and hence they were not further processed. It is noteworthy that these samples originated either from trenches outside the settlement, although in direct proximity to its external buildings, or on its borders (Table 1). The five remaining samples deriving from the buildings and the squares of the settlement were fine and were successfully dated.

RESULTS AND DISCUSSION

The radiocarbon dating results of the five successfully dated samples, all of *capra/ovis* species, are shown in Table 2. The calibrated ages, given with 1σ and 2σ, were obtained using the program OxCal v.4.4.4 (Bronk Ramsey 2021) with the latest dataset of 2020 (Reimer et al. 2020).

It is interesting to note that the δ¹³C values, typical for sheep and goat species during the Bronze Age in mainland Greece and the islands (Maniatis and Arvaniti 2015), show remarkable consistency, indicating that the bones did not suffer any alteration due to taphonomic processes and that the sample treatment and preparation was meticulous.

The radiocarbon dates and consequently the calibrated ages are very similar, verifying in this way the archaeological evidence that indicates the existence of one and only one main occupation period, Skarkos II, in the larger part of Skarkos hill, where all the analyzed samples come from. This corresponds to EC II, the time of the Keros-Syros culture. The calibrated ages cluster in the middle of the 3rd millennium BC. These dates determine the last stages of

Table 1 Animal bone (capra/ovis) samples and their archaeological coordinates.

Lab code	Locational details	Stratigraphical details	Context
DEM-1923	Trench 26/E14 Square 7	Destruction Level (Level 2) Layer 14	In a debris layer a little above the natural bedrock with diagnostic Early Cycladic II fragmentary pottery
DEM-2385	Trench 26/A16 Building Beta, room 5	Destruction Level (Level 2) Layer 12	From the debris on the floor level of the ground floor or a little above with diagnostic Early Cycladic II fragmentary pottery
DEM-2386	Trenches 26/A16 and 19/T16 Square 4	Ashy Layer (Level 3) Layer 25	From a thick levelled layer of ash and refuse spread over the square 4 floor. The square was used for preparing food and organizing communal meals since both circular portable hearths and fixed baking pans were found there. The pottery included distinctive forms associated with the Early Cycladic II period such as saucers and sauceboats both local and <i>Urfirmis</i> . Furthermore, four schematic marble figurines of the Apeiranthos type were recovered there.
DEM-2387	Trench 26/Δ13 Building Sigma, room 226	Destruction Level (Level 2) Layer 4	From a deposit of debris, a little above the floor of the ground floor. The ceramics contain storage and cooking vessels and diagnostic Early Cycladic II vessels such as shallow bowls.
DEM-2388	Room 244 Building Iota Epsilon Trenches 26/B11, 26/B12 and 26/A12	Ashy Layer (Level 3), Layers 9	From a thick levelled layer of ash and refuse spread over the floor of room 244 ground floor, which was used as a kitchen. A baking pan set firmly into the ground was found in situ in the southeast corner. Fine and semi-fine pottery includes characteristic Early Cycladic II drinking and eating shapes such as the shallow, the deep bowl, and the saucer. Moreover, a schematic marble figurine of the Apeiranthos type was collected there.

(Continued)

Table 1 (Continued)

Lab code	Locational details	Stratigraphical details	Context
<i>Samples that failed</i>			
DEM-1916	Outside Building Sigma on the west boundary of the settlement Trench 26/E13	Ashy Layer (Level 3) Layer 7	In the deposit of a furnace with diagnostic Early Cycladic II fragmentary pottery
DEM-1918	Area 10 outside the settlement entrance leading to Square 1 Trench 26/B19	Destruction Level (Level 2) Layer 4	In a debris layer well above the natural bedrock with diagnostic Early Cycladic II fragmentary pottery
DEM-1924	Area 9 outside the settlement entrance leading to Street 1 Trenches 26/Z18 & 26/Z17	Destruction Level (Level 2) Layer 7	In a debris layer well above the natural bedrock with diagnostic Early Cycladic II fragmentary pottery
DEM-1925	Area 9 outside the settlement entrance leading to Street 1 Trenches 26/Z18 & 26/Z17	Destruction Level (Level 2) Layer 7	In a debris layer well above the natural bedrock with diagnostic Early Cycladic II fragmentary pottery

Table 2 Radiocarbon dating results of the successfully dated samples.

Laboratory code	Sample location	Age ¹⁴ C (BP)	δ ¹³ C (‰)	% C combusted	Calibrated age (BC)	Probabilities
DEM-1923	Trench 26/E14 Square 7	3990 ± 30	-19.52	36.0	2566–2470 2577–2460	(68.2%) (95.4%)
DEM-2385	Trench 26/A16 Building <i>Beta</i> , room 5	4016 ± 30	-19.39	33.0	2572–2476 2621–2467	(68.3%) (95.4%)
DEM-2386	Trenches 26/A14 and 19/T16 Square 4	4000 ± 30	-19.78	42.3	2568–2472 2572–2463	(68.3%) (95.4%)
DEM-2387	Trench 26/Δ13 Building <i>Sigma</i> , room 226	3994 ± 30	-19.66	29.0	2567–2471 2577–2462	(68.3%) (95.4%)
DEM-2388	Building <i>Iota Epsilon</i> , Room 244 Trenches 26/B11, 26/B12 and 26/A12	3982 ± 30	-19.35	30.0	2566–2467 2578–2358	(68.3%) (95.4%)

Table 3 Summarized results of the single-phase modelling analysis of Skarkos samples.

Skarkos ECII Phase	95% probability range	Weighted mean	Median	Consensus
Start boundary	2612–2473 BC	2549 ± 41 BC	2554 BC	2550 BC
End boundary	2565–2430 BC	2497 ± 42 BC	2494 BC	2500 BC

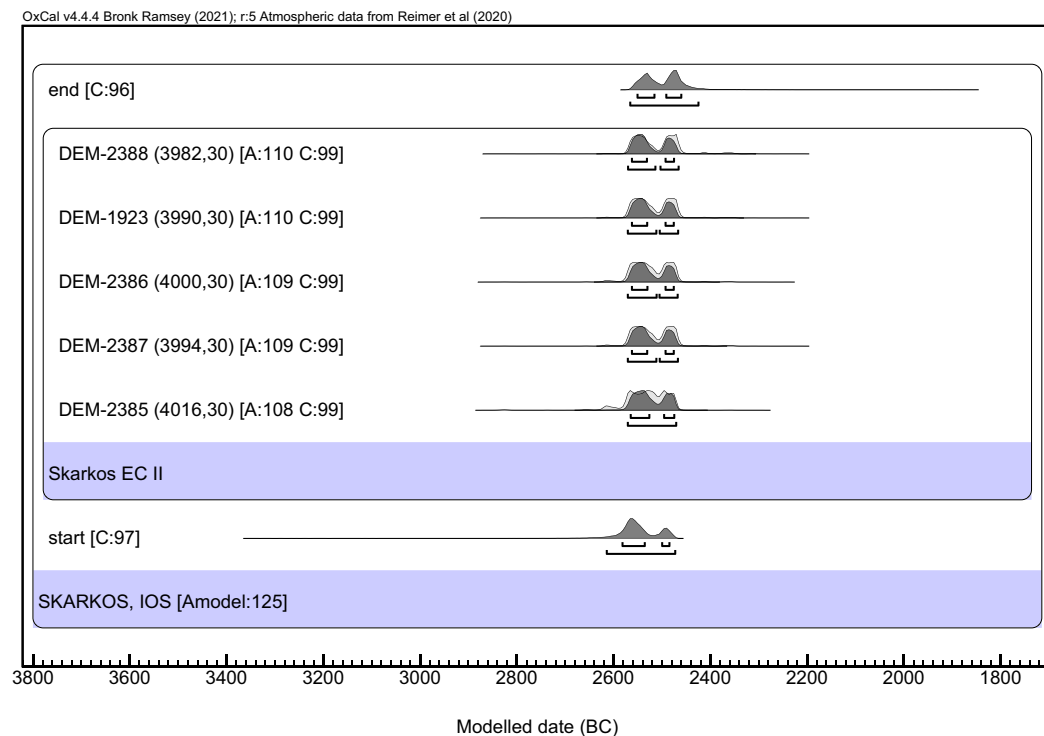


Figure 11 Modelled dates of Skarkos II using a single-phase Bayesian analysis model.

Skarkos II before its final destruction. A statistical treatment and modelling of the results with Bayesian Analysis (Bronk Ramsey 2009a, 2009b) was performed using one phase model. This gave the output probability distributions for 1σ (68.2%) and 2σ (95.4%) as shown in Figure 11. Due to a wiggle in the calibration curve at this period, the calibrated age ranges split into two-peak distributions, as can be seen in this plot. Nevertheless, the *Start* and *End* boundaries despite the splitting, show an overall 2σ probability distribution with a relatively narrow width.

The results of the analysis are shown in Table 3. As it appears the final stage of Skarkos II (EC II) starts at a mean date of 2549 ± 41 BC and ends at a mean date of 2497 ± 42 BC, giving a mean rounded-up duration of **2550–2500 BC**. This most likely represents approximately the last 50 years of the settlement at Skarkos in the EC II period.

In order to place the dates of Skarkos II within the absolute time frame of the EC chronology we ran a multi-phase Bayesian analysis model using published dates from other Cycladic islands covering the cultural phases EC I, EC I/II, EC II, EC II/III and EC III (Table 4).

Table 4 Samples from Skarkos and other sites included in the multi-phase EC model.

Lab no	Sample type	Site and cultural phase	Radiocarbon date BP	Reference
OxA 7470	Shell	FN-EC I, Zas IIB	4345 ± 40	1
OxA 7471	Wood	EC I (Lakkoudhes phase), Zas III	4425 ± 40	1
OxA 3297	Animal bone	EC I/II (Kamos group), Markiani II	4380 ± 100	2
OxA 4003	Animal bone	EC I/II (Kamos group), Markiani II	4390 ± 65	2
OxA 4004	Animal bone	EC I/II (Kamos group), Markiani II	4160 ± 65	2
OxA 3295	Animal bone	EC II (Keros-Syros culture), Markiani III	4105 ± 80	2
OxA 3293	Animal bone	EC II (Keros-Syros culture), Markiani III	4090 ± 90	2
OxA 3296	Animal bone	EC II (Keros-Syros culture), Markiani III	4080 ± 75	2
OxA 3294	Animal bone	EC II (Keros-Syros culture), Markiani III	4060 ± 75	2
OxA 3292	Animal bone	EC II (Keros-Syros culture), Markiani III	3920 ± 80	2
OxA 22754	Charcoal	EC II (Keros-Syros culture), Dhaskalio A	4065 ± 30	3
DEM-2385	Animal bone	EC II (Keros-Syros culture), Skarkos II	4016 ± 30	3
DEM-2387	Animal bone	EC II (Keros-Syros culture), Skarkos II	3994 ± 30	3
DEM-2386	Animal bone	EC II (Keros-Syros culture), Skarkos II	4000 ± 30	3
DEM-1923	Animal bone	EC II (Keros-Syros culture), Skarkos II	3990 ± 30	3
DEM-2388	Animal bone	EC II (Keros-Syros culture), Skarkos II	3982 ± 30	3
OxA-22745	Charcoal	EC II/III (Early Kastri group), Dhaskalio B	4021 ± 29	3
OxA-22746	Charcoal	EC II/III (Early Kastri group), Dhaskalio B	3876 ± 29	3
OxA-22747	Charcoal	EC II/III (Early Kastri group), Dhaskalio B	4033 ± 30	3
OxA-22753	Charcoal	EC II/III (Early Kastri group), Dhaskalio B	3849 ± 31	3
OxA-22755	Charcoal	EC II/III (Early Kastri group), Dhaskalio B	3921 ± 31	3
OxA-22756	Charcoal	EC II/III (Early Kastri group), Dhaskalio B	3933 ± 31	3
OxA-22749	Charcoal	EC III, Dhaskalio C	3923 ± 29	3
OxA-22748	Charcoal	EC III, Dhaskalio C	3919 ± 28	3
OxA-22751	Charcoal	EC III, Dhaskalio C	3904 ± 30	3
OxA-22761	Charcoal	EC III, Dhaskalio C	3870 ± 30	3
OxA-22758	Charcoal	EC III, Dhaskalio C	3852 ± 29	3
OxA-22750	Charcoal	EC III, Dhaskalio C	3841 ± 29	3
OxA-22760	Charcoal	EC III, Dhaskalio C	3837 ± 30	3

1. Manning (2008).

2. Renfrew et al. (2006); Manning (2008); Renfrew et al. (2012).

3. Renfrew et al. (2012); Bronk Ramsey et al. (2013).

In particular, we used two FN/EC I dates from the Zas cave in Naxos reported by Manning (2008), three EC I/II dates from Markiani II (Kampos group) (Renfrew et al. 2006, 2012; Manning 2008), five EC II dates from Markiani III and one date from Dhaskalio-A (Keros-Syros culture) (Renfrew et al. 2006, 2012; Bronk Ramsey et al. 2013). We also used five (EC II/III) dates from Dhaskalio-B (Early Kastri group) (Renfrew et al. 2012; Bronk Ramsey et al. 2013) and seven (EC III) dates from Dhaskalio-C (Renfrew et al. 2012; Bronk Ramsey et al. 2013). In this analysis we have not included in the phase EC II/III the samples from Markiani IV (thought to belong to EC II/III, Early Kastri group) accepting the suggestion by Renfrew et al. (2012) that the pottery of Markiani IV is not well studied and might belong to a later phase, probably EC III. It should be noted that there are no radiocarbon dates available from either Ayia Irini or Phylakopi.

This multi-phase analysis was approached in two slightly different models. Model 1 (Figure 12): the Skarkos dates are included in the same phase (Keros-Syros culture) with Markiani III, and Dhaskalio-A (one sample). Model 2 (Figure 13): the Skarkos dates are separated with a boundary following the Markiani III, and Dhaskalio-A (one sample) dates, treating the Skarkos II dates as a separate phase that follows the Markiani II and Dhaskalio-A.

The first model assumes that Markiani III, Dhaskalio-A, and Skarkos are practically synchronous based on the fact that, as discussed above, the pottery assemblage of the Markiani III period of Amorgos bears a great resemblance to that of Skarkos II, despite the fact that it does not comprise fine imported wares.

The second model treats the Skarkos II dates as a separate phase that follows the Markiani III and Dhaskalio-A, given the fact that the Skarkos II dates appear to be slightly later so that by grouping them in a different phase we allow the model to calculate any time difference with the group Markiani III- i.e. Markiani III - Dhaskalio-A that may exist.

Model 1 produces an overall model agreement ($A_{\text{mod}} = 86$) and all samples have an individual agreement over 70 (Figure 12).

Model 2 produces a better overall agreement ($A_{\text{mod}} = 102$), but with one sample from Markiani III (OxA-3292) agreeing less well in that phase ($A = 44$) (Figure 13).

We believe that model 2, with Skarkos II as a separate later phase within the Keros-Syros culture period (EC II), is probably closer to reality. However, we report here both. The numerical analysis results for the phase transition boundaries from the two models are shown in Tables 5 and 6 respectively. As it appears the new Skarkos dates representing the final stages of the occupation in the EC II period, treated together with data from other Cycladic sites, modify to a certain extent the dates proposed in the past particularly for the transition boundary from Kampos group to Keros-Syros culture (EC I/II to EC II) (Manning 2008; Renfrew et al. 2012; Bronk Ramsey et al. 2013). This transition was reported at 2650 BC by Manning (2008) using the dates from Zas and Markiani, and some bones from Keros-Kavos dates. The same transition boundary was increased to 2750 BC by Renfrew et al. (2012) and Bronk Ramsey et al. (2013) using again the Markiani II and III dates and the Dhaskalio A, B and C dates. The same date, 2750 BC was also reported by our previous paper (Arvaniti and Maniatis 2018), using the same date set as Renfrew et al. (2012) plus the Palamari (Skyros) dates (Maniatis and Arvaniti 2015) grouped with Dhaskalio B in the Early Kastri group phase (EC II/III).

Model 1

OxCal v4.4.4 Bronk Ramsey (2021); r:5 Atmospheric data from Reimer et al (2020)

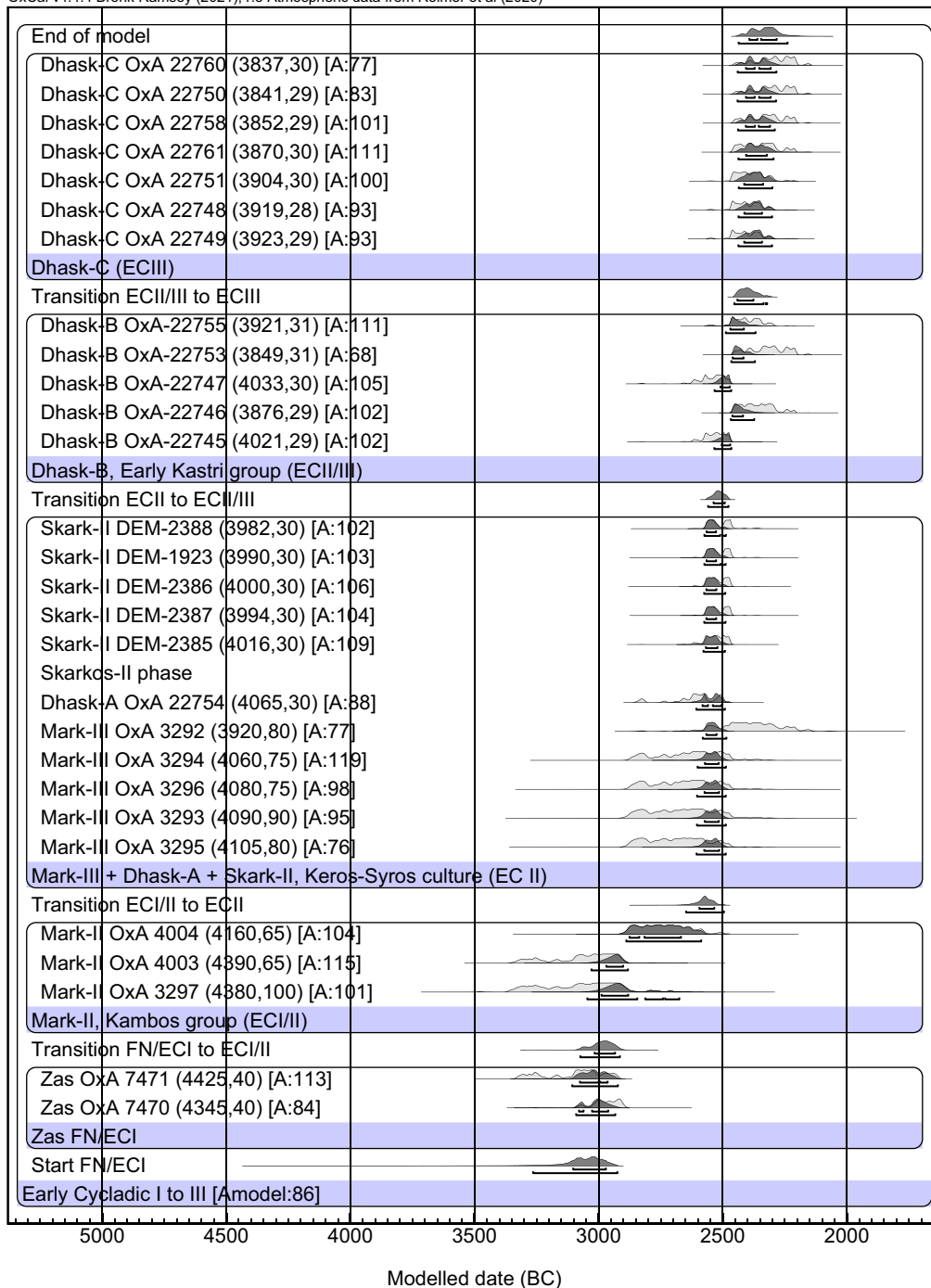


Figure 12 Model 1: Bayesian analysis of the Skarkos dates together with samples from Zas Cave, Markiani and Dhaskalio using a five-phase model (FN/EC I, EC I/II, EC II, EC II/III, EC III). The Skarkos dates in this model are grouped in the same phase (EC II) with Markiani III and Dhaskalio-A (one sample).

Model 2

OxCal v4.4.4 Bronk Ramsey (2021); r:5 Atmospheric data from Reimer et al (2020)

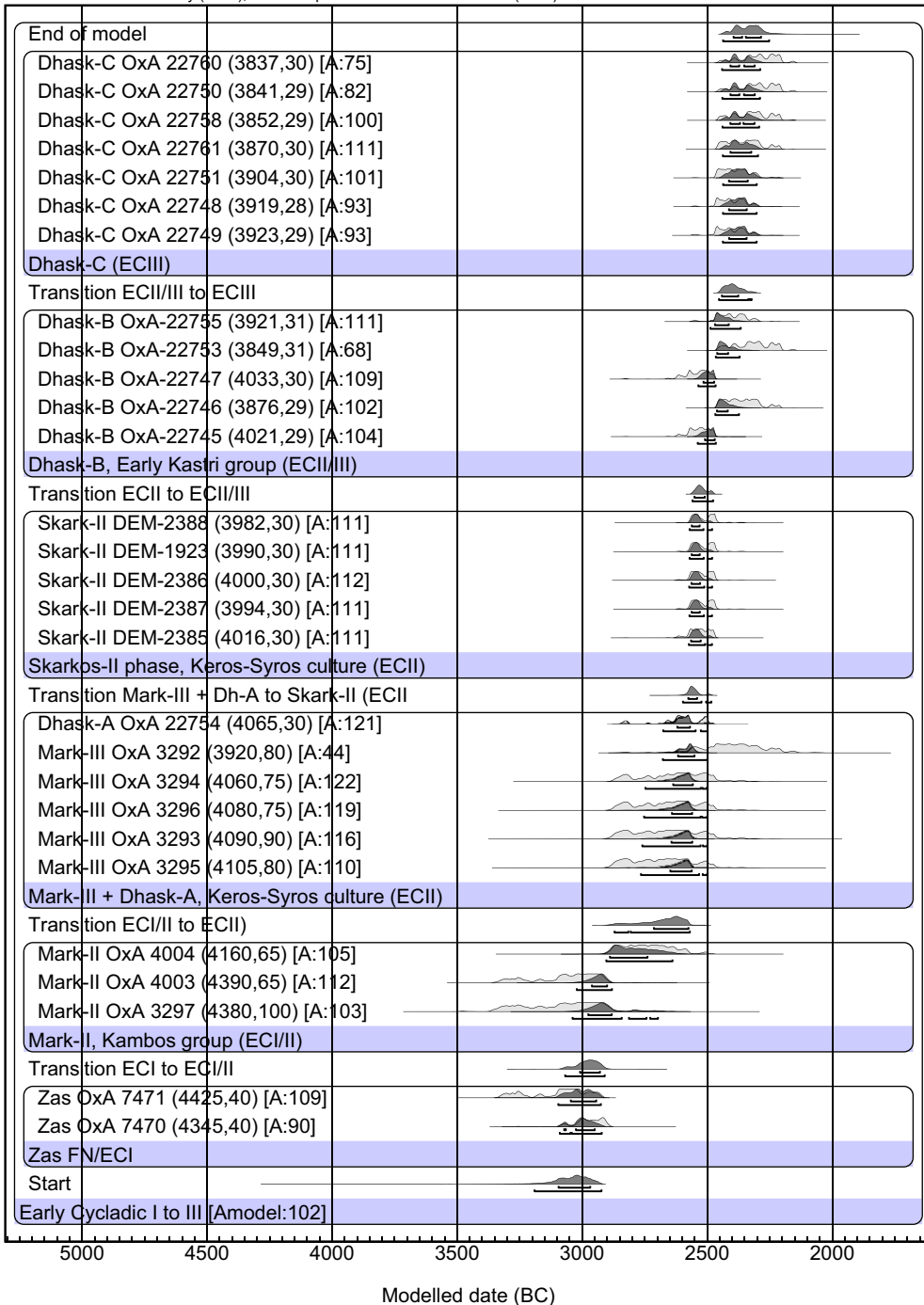


Figure 13 Model 2: Bayesian analysis of the Skarkos II dates together with samples from Zas Cave, Markiani and Dhaskalio using a six-phase model (FN/EC I, EC I/II, EC II, EC II/III, EC III). The Skarkos dates in this model are separated by a boundary from Markiani III and Dhaskalio-A anticipating a possible later subphase in the EC II phase.

Table 5 Numerical results of the output of Model 1 (five-phase model, with Skarkos dates in same phase as Markiani III and Dhaskalio) (Figure 12).

Transition boundaries	95.4% probability range	Weighted mean	Median
Start of model	3236–2925 BC	3066 BC	3048 BC
Zas to Mark-II (EC I to EC I/II, Kampos group)	3075–2915 BC	2987 BC	2983 BC
Mark-II to (Mark-III + Dhask-A + Skarkos) (EC I/II to EC II, Keros-Syros culture)	2646–2496 BC	2573 BC	2571 BC
(Mark-III + Dhask-A + Skarkos II) to Dhask-B (EC II to EC II/III, Early Kastri group)	2555–2476 BC	2514 BC	2514 BC
Dhask-B to Dhask-C (EC II/III to EC III)	2455–2336 BC	2398 BC	2402 BC
End of model	2436–2242 BC	2333 BC	2332 BC

Table 6 Numerical results of the output of Model 2 (six-phase model, with Skarkos dates in different phase from Markiani III and Dhaskalio) (Figure 13).

Transition boundaries	95.4% probability range	Weighted mean	Median
Start of model	3208–2925 BC	3050 BC	3036 BC
Zas to Mark-II (EC I to EC I/II, Kampos group)	3070–2911 BC	2979 BC	2975 BC
Mark-II to (Mark-III + Dhask-A) (EC I/II to EC II, Keros-Syros culture)	2871–2570 BC	2682 BC	2661 BC
(Mark-III + Dhask-A) to Skarkos II (EC II, Keros-Syros culture)	2597–2485 BC	2555 BC	2559 BC
Skarkos to Dhask-B (EC II to EC II/III, Early Kastri group)	2560–2477 BC	2524 BC	2528 BC
Dhask-B to Dhask-C (EC II/III to EC III)	2454–2321 BC	2397 BC	2401 BC
End of model	2438–2252 BC	2337 BC	2335 BC

However, when we include the Skarkos II dates the transition boundary to the EC II phase comes down to 2700 BC for model 2, which is probably more realistic. We believe this date may represent more truly the transition (EC I/II to EC II) because the Skarkos II samples resulting from well stratified layers define much better the end of the EC II phase and hence the preceding period, than Markiani or Dhaskalio A alone. In particular, this transition was defined in the previous works with just three radiocarbon dates from Markiani II (EC I/II) and five dates from Markiani III (EC II) and two from Dhaskalio A (OxA-22754 and OxA-22757). All those dates exhibit very large age ranges due to initial large errors in the BP dates and the wiggles in the calibration curve at that period. Hence, in the Bayesian analysis model the transition boundary of EC I/II to EC II is a bit floating and its overall distribution and mean value can be influenced by the date of one or two samples still producing an output with a reasonable overall agreement. For example, the sample OxA-22757 (R45) from Dhaskalio A has a very high age for this period and pushes the transition to a higher date (2750 BC). The context of this sample together with the context of sample R44 (OxA-22756) were discussed and debated by Bronk Ramsey et al. (2013). Besides, the Dhaskalio samples are small charcoal fragments and there is always the chance that may be exhibiting an old wood effect to

Table 7 Approximate chronologies proposed after the Skarkos dates with the two models, using the mean dates rounded to the closest 100th.

Period	Chronology (Model 1)	Chronology (Model 2)
EC I/II (Kampos group)	3000–2550 BC	3000–2700 BC
EC II (Keros-Syros culture)	2600–2500 BC	2700–2500 BC
EC II (Skarkos phase II)		(2550–2500 BC)
EC II/III (Early Kastri group)	2500–2400 BC	2500–2400 BC
EC III to end of Dhaskalio C	2400–2350 BC	2400–2350 BC

a lesser or higher degree (Renfrew et al. 2012). We therefore decided to leave these two samples out from the present statistical analysis.

Nevertheless, the definition of the transition from the EC I/II (Kampos group) to EC II (Keros-Syros culture), hence the beginning of the EC II phase, relied in the past on just three dates and with large errors for the preceding period Markiani II (EC I/II). We have now added to the EC II period precise and repeatable dates from Skarkos which certainly more strongly define statistically the last stages of the EC II period.

In every case we should not consider these dates for the transition EC I/II to EC II, as securely fixed given the fact that they are based on limited available data from the preceding periods and dates with large uncertainties. The transition date would be fixed better if there were more individual dates from the preceding periods. Colin Renfrew in discussing the Markiani radiocarbon dates suggests there may possibly be a putative Early Markiani III gap (occupation gap?) of about 100 years not well represented in the radiocarbon dates or in the contexts excavated (Renfrew et al. 2006). This of course cannot be visualized at present and one cannot predict what dates such a stratigraphic layer if existed would give. We are expecting to obtain and date samples from the newly discovered preceding period of Skarkos (Skarkos I), in the near future as the study of the material proceeds

For the present time it is safe to say that the addition of the new Skarkos dates improve on previously published models, based on the same published dates, by extending the span of the dates for the EC II period with higher precision dates. Based on this we can perhaps propose a new tentative chronology for the Cycladic phases as presented in Table 7, with the reservations explained above. As expected, the period whose absolute date span is noticeably modified, is the EC II period. Accepting Model 2 as more accurate this can now be 2700–2500 BC. This is approximately the same with the dates suggested by Manning (2008) at 2650–2500 BC, and 50 years younger than those suggested by Renfrew et al. (2012) and Bronk-Ramsey et al. (2013) at 2750–2550 BC.

The chronologies for the periods EC I/II, EC II/III and beginning of EC II are not much influenced by the new Skarkos dates. In comparing the Skarkos dates by themselves (2550–2500 BC) with dates from other non-Cycladic islands such as Palamari in Skyros and Aghios Ioannis Potos in Thasos, one observes the following:

Palamari phases IIa and IIb, correspond to early EBA II/III and late EBA II/III (Early Kastri group) respectively. Palamari IIa-IIb culturally follows the Keros-Syros culture (EC II). The modelled dates that cover these two phases in Palamari are 2550–2400 BC

(Maniatis and Arvaniti 2015). This implies that the beginning of EBA II/III at Palamari is synchronous with Skarkos, but its end coincides with the end of EC II/III.

Aghios Antonios Potos in Thasos offers only two dates in the EB II period which give mean modelled dates of 2750 BC and 2600 BC (Maniatis et al. 2015) falling in the early part of EC II period, preceding the Skarkos dates.

CONCLUSIONS

We have radiocarbon-dated the main settlement of Skarkos (Skarkos II) on the Cycladic island of Ios, and particularly the last stages of occupation, using a set of animal bone samples. It is the first time the main settlement of Skarkos is dated in absolute terms filling the chronology of the Cycladic EBA II culture. The dates show that the absolute chronology of the last stages of Skarkos II is defined between circa 2550 and circa 2500 BC. The dates also confirm the archaeological evidence that the main occupation period is dated archaeologically to the EC II period (Keros-Syros culture).

These radiocarbon dates represent a duration of approximately 50 years for the human activity at the site prior to the destruction and abandonment of the site and define accurately the end of the EBA II Skarkos occupation and the end of EC II at 2500 BC.

Furthermore, in order to compare the new Skarkos dates with the overall Cycladic chronology and refine better the EC II phase, we treated the Skarkos dates together with published dates from other sites exhibiting preceding and following phases. We ran a multi-phase Bayesian analysis model in two versions. Model 1 with the Skarkos dates in the same phase as Markiani III and Dhaskalio A (one sample) and Model 2 with Skarkos dates as a separate phase subsequent to Markiani III and Dhaskalio A. The latter model seems to reflect more truly the events suggesting a range for the EC II period of 2700–2500 BC respectively.

The Skarkos dates (2550–2500 BC) cluster in the later part of this period. Future work and more radiocarbon dates, as planned, from the preceding EBA period at Skarkos (Skarkos I) are necessary to improve the statistical analysis and define the whole duration of Skarkos II settlement and the transition date for the beginning of the EC II more accurately.

ACKNOWLEDGMENTS

We would like to thank the technicians of the Laboratory of Archaeometry, NCSR Demokritos, Mrs Kyriaki Goggidou, and Marigo-Eirini Kyriazi for the meticulous pre-treatment of the samples. We are also indebted to Prof. Colin Renfrew, of Cambridge University for his valuable comments on the manuscript. Finally, we would like to thank the anonymous reviewer for his helpful comments/suggestions.

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