# GIS AND HISTORICAL GEOGRAPHICAL ANALYSES OF THE RECONSTRUCTED ANCIENT COURSE OF THE TIGRIS IN THE NORTHERN PART OF SOUTHERN MESOPOTAMIA[1)]

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**Abstract**

It is widely accepted that from the beginning of the 4th millennium BCE until the Neo-Babylonian period around the end of the 7th century BCE in the northern part of southern Mesopotamia, the ancient course of the Tigris may have flowed to the east of its present course. However, studies in the late 1990s and later have indicated alternative possibilities. This study investigates and analyzes the validity of past theories on the location of the ancient course of the Tigris in this area with the aid of 3D contour maps of southern Mesopotamia developed from Shuttle Radar Topographical Mission Digital Elevation Model (DEM) and Advanced Land Observing Satellite DEM data using Geographical Information System, satellite imagery from World Imagery, Corona satellite photographs, and other topographical information on the ancient course of the Tigris found in ancient written sources. Using these comparative validation analyses, the location of the ancient course of the Tigris in the northern part of southern Mesopotamia from the beginning of the 4th millennium BCE until the Neo-Babylonian period is ascertained.

## I. Introduction: Previous Studies, Study Methods, and Goal of This Work

Four hypothetically reconstructed ancient courses have been proposed for the Tigris in and around Baghdad and to its south in the northern part of southern Mesopotamia for the period from the mid-Holocene until the Neo-Babylonian period, around the end of the 7th century BCE. Two of these, proposed by R. McC. Adams [1965] and C. Hritz [2010, 184–203], place the Tigris to the east of its present course. A third one, initially proposed by S. W. Cole and H. Gasche [1998, 1–64; 1999, 87–110; 2001, 197–210] and later together with M. Tanret, and K. Verhoeven [2002, 531–544, maps 1–2], places it in roughly the same course as the present course, extending to the south and the west of the present course. The final proposal, by J. Jotheri [2016, 151–156, figs. 4.29–4.35], places the earlier course to the west of the present one and a later course in roughly the same course as at the present, in two different periods.

More details for these four reconstructions are given below. This discussion begins with Adams's reconstruction, followed by those by Cole and others, Hritz, and Jotheri. The validity of each reconstruction is examined and verified, using the same method as a previous study by this article's author, which used GIS analyses and various pieces of topographical information on the ancient course of the Tigris contained in written sources to reconstruct the ancient course of the Tigris in the southern part of southern Mesopotamia in the Ur III period [Kawakami 2021, in press]. The same methodological discussion and mention of its limitations as given in that article are quoted below with a goal of this article.

The ArcGIS 10.8 software published by Esri Inc. was used for the topographic mappings and analyses presented in this study. The Shuttle Radar Topographical Mission (SRTM) Digital Elevation

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Model (DEM) and Advanced Land Observing Satellite (ALOS) DEM were used to display 3D contour maps to discern the fluvial levees of the ancient course of the Tigris[2]. Initial hydrological analyses were carried out with these DEMs through GIS[3]. However, modern topographical data make it impossible to infer the flow paths of the ancient courses of rivers and watercourses that existed from a few hundred to a few thousand years ago. The fluvial levees of the ancient courses of the watercourses were observed on the SRTM and ALOS DEM 3D contour maps using visual examination.

The SRTM DEM features 3-second (about 90-meter) interval mesh data of the southern Mesopotamian region measured by radar on board the Space Shuttle Endeavour in 2000—the data have been available for free since 2003. Due to their low resolution, of approximately 90 meters, structures such as modern maintained roads and irrigation canals are smoothed out and do not appear. For this reason, the geomorphological features of tens of kilometers of fluvial levees of the ancient courses of rivers and watercourses can be clearly seen.

The ALOS DEM dataset has a resolution of approximately 30 meters; it has been available for free since 2016. It was created by the Japan Aerospace Exploration Agency, using the Panchromatic Remote-sensing Instrument for Stereo Mapping on board the ALOS Daichi. As its data have a resolution that is higher than that of the SRTM DEM, it was used in combination with the SRTM DEM 3D contour maps to complement the more detailed geomorphological features of fluvial levees of the ancient courses of rivers and watercourses, which are not shown on the SRTM DEM 3D contour maps. This makes it possible to reconstruct them more accurately. The 3D contour maps shown in figures below were prepared from these SRTM DEM and ALOS DEM data.

In addition to these two DEMs, the satellite imagery from World Imagery, which can be displayed directly on GIS via the internet, was also used and prepared in the figures below[4]. Corona satellite photographs were used as well[5]. These made it possible to complement the geomorphological features of the fluvial levees of the ancient courses of rivers and watercourses, which do not appear on the 3D contour maps of the two DEMs.

The Tigris and Euphrates Rivers have substantially influenced the process of land formation in the alluvial plain of southern Mesopotamia. The present course of the Tigris begins on the southern slopes of the Taurus-Zagros Mountains of eastern Anatolia. In northern Iraq, the Tigris cuts deeply into the surrounding plain, forming a narrow alluvial zone bounded by cliffs and hills. South of Samarra, the river enters the extensive Mesopotamian alluvial plain, where at first, it forms a meandering single channel and then a braided one, shortly before joining the present Euphrates to form the Shatt al-Arab, finally emptying into the Persian Gulf [Hirschfeld 1997, 206].

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2) See https://www.mizuho-ir.co.jp/publication/report/2016/mhir12_eros_03.html for more information on the freely available SRTM and ALOS DEMs (in Japanese). Apart from the ALOS DEM, as described on the same site, there is also another freely available DEM. It is the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Global Digital Elevation Model (GDEM) with resolution of 30 meters that is the same as the freely available ALOS DEM. However, it is reported that it is older than the ALOS DEM and contains more errors, so the freely available ALSO DEM is used in this study.

DEMs with very high resolution are also available. The ALOS DEM is also available with about 5-meter resolution: https://www.eorc.jaxa.jp/ALOS/aw3d/index.htm (in Japanese). The ALOS World (AW) 3D Digital Surface Model (DSM) and the AW 3D Digital Terrain Model (DTM) with resolution of half a meter to 2 meters are also available: https://www.aw3d.jp/ (in Japanese). However, they are too expensive to make their use practical for this study.

3) Hydrological analysis is a tool used in GIS based on DEM raster data to establish a water system model, which is used to study the hydrological characteristics and simulate the hydrological process of the surface to develop forecasts of hydrological patterns.

4) For World Imagery, see https://www.arcgis.com/home/item.html?id=10df2279f9684e4a9f6a7f08febac2a9. It provides 1-meter imagery or better satellite and aerial imagery in many parts of the world and lower resolution satellite imagery worldwide.

5) For Corona satellite photographs, see https://corona.cast.uark.edu/. The Corona satellite project was launched during the Eisenhower administration in the late 1950's. The goal was to take photographs of sensitive strategic areas, at the time, mainly the Soviet Bloc and China, and the Middle East was added in the 1960s. These photographs, some 860,000 in total, were declassified in 1996 and are publicly available at minimal cost through the United States Geological Survey. The photographs, taken by numerous missions of the Corona program between 1959 and 1972, include Mesopotamia [Hritz 2005, 67–72].

The present course of the Euphrates can be divided into a number of distinct geographic units. First, the Upper Euphrates begins in eastern Anatolia, while the Middle Euphrates receives Syrian tributaries. Then, the river crosses into Iraq near the ancient site of Mari and enters the Mesopotamian floodplain. The Lower Euphrates consists of a series of sub-geomorphological units. In a typical alluvial plain, its braiding streams create natural levees or river embankments, characterized by seasonal inundation and alluvial flats, reaching its closest point to the present course of the Tigris near ancient Sippar and modern Baghdad. The river then enters the delta plain and divides into two branches, which rejoin after passing Samawah to create a marsh/lake environment. The river finally joins the present Tigris to form the Shatt al-Arab in the estuarine zone [Zarins 1997, 287].

Because the Tigris and Euphrates flowed in the same courses for hundreds of years at a time across the very flat alluvial plain of southern Mesopotamia, their fluvial levees remain across a surface of tens of kilometers. The network of the fluvial levees of their ancient courses can be discerned on the SRTM and ALOS DEM 3D contour maps. They can be clearly displayed by adjusting the GIS color ramp settings, causing color changes from white at lower elevations to black at higher ones or the reverse[6]. The network of the fluvial levees of the ancient courses of the rivers is discernible on 3D contour maps, and the fluvial levees of the ancient courses of the Tigris and Euphrates can be identified by comparing them with the four hypothetically reconstructed ancient courses proposed for the Tigris in the northern part of southern Mesopotamia by Adams, Cole and others, Hritz, and Jotheri.

However, there are limitations to discerning the fluvial levees of the ancient courses of the Tigris and Euphrates on the SRTM and ALOS DEM 3D contour maps. The fluvial levees from the mid-Holocene until the Neo-Babylonian period, around the end of the 7th century BCE, the period examined in this study, may have been varied and erased by later sediment deposits caused by the large-scale construction of irrigation canals and other water facilities for agriculture during the medieval Islamic period. The levees appertaining to this area are unfortunately not discernible. It is also difficult to determine which fluvial levees of the ancient courses of rivers and watercourses relate to the Euphrates and which to the Tigris, as well as whether they date from even more ancient times than our period or a later time, such as the medieval Islamic period.

Finally, the positional relationship of the four hypothetically reconstructed ancient courses is compared with the further lower reach of the ancient course of the Tigris, which was initially assumed by R. D. Biggs [1965, 95–102] from a letter of the Kassite period and presumed later by W. Heimpel [1990, 204–213] and P. Steinkeller [2001, 22–84] from documents of the Ur III period, and most recently reconfirmed for the Tigris in the northern and central part of Sumer in the southern part of southern Mesopotamia in the author's previous study [Kawakami 2021, in press]. Then, the whereabouts of the ancient course of the Tigris in the northern part of southern Mesopotamia are ascertained by the results of this comparative verification and related analyses.

## II. Ancient Course of the Tigris in the Northern Part of Southern Mesopotamia

### II.1. Reconstruction by R. McC. Adams

The first hypothesis put forward for the ancient course of the Tigris in and around Baghdad and to the south of the city in the northern part of southern Mesopotamia was proposed by Adams [1965]. His theory became widely accepted. Adams thought that, in general, ancient settlements would likely not be established far from fluvial courses. This implied that rivers, their channels, and artificial canals would naturally flow from sites upstream to nearby contemporary sites downstream.

6) This GIS tool presents elevation data according to one or another set color scheme to indicate various geological features.

Using this reasoning, he established settlement patterns for ancient sites using typological analyses of pottery shards collected from surface remnants. Then, following his studies and analyses of the patterns of inhabited sites lying in the Diyala region east of the present course of the Tigris in relation to their histories of settlement, he established an approximate network for fluvial courses in the region. He concluded that the ancient course of the Tigris was to the east of its present course, at least from the beginning of the 4th millennium BCE until the Neo-Babylonian period, around the end of the 7th century BCE, afterward changing its flow to the west to form its present course[7]. Thus, he established a possible ancient course of the Tigris to the east of its present course on the latitude between the north of Baghdad and the diversion point of the Gharrāf Canal. As he had already reported in his work with Jacobsen [1957, 96–97; 1960, 175–179; 1969, 103–109], Adams [1957a, 139–141; 1957b, 270–273; 1958, 101–103, figs. 1–6] continued to argue that the Tigris did not affect the subsistence of inhabitants in the lower Mesopotamian alluvium [Jacobsen and Adams 1958, 1252]. Instead, according to this view, the Euphrates supplied water to all major channels in the southern Mesopotamian alluvium. This argument has been accepted by other scholars[8].

Adams's reconstruction of the ancient course of the Tigris was scanned and geo-referenced with 3D contour maps developed from the SRTM DEM and ALOS DEM data in GIS, and it was then traced and reconstructed as a double grayish line on the SRTM DEM 3D contour map (Fig. 2)[9]. However, unlike the SRTM DEM 3D contour map (Fig. 1), the ALOS DEM 3D contour map (Fig. 3), the World Imagery Map (Fig. 4), and the Corona satellite photographs, no levee of a fluvial course can be discerned on Adams's reconstructed fluvial line. This suggests that either this course was buried under the heavy silt sedimentation of the Tigris itself or that the reconstruction is in fact incorrect.

### II.2. Reconstruction by S. W. Cole, H. Gasche, H. Tanret, and K. Verhoeven

The second hypothesis for the reconstruction of the ancient course of the Tigris in and around Baghdad and to the south was initially proposed by Cole and Gasche [1998, 1–64; 1999, 87–110; 2001, 197–210]. They later slightly modified this proposal with the aid of Tanret and Verhoeven [2002, 531–544, maps 1–2; Hritz 2006, 420]. For this, topographical survey records, aerial photos, and satellite images were used to create a 3D contour map with a gradation of 1-meter intervals on a Universal Transverse Mercator map projection. On their 3D contour map, like those of the SRTM DEM and ALOS DEM 3D, the meandering levees of a fluvial network are discernible. On their map, they found three fluvial meander levees, branching off from or in the vicinity of the present course of the Euphrates, with two joining the present course of the Tigris. They also found a large and wide fluvial mender levee running to the southeast of the ancient site of Seleucia. They inferred that this was likely created by the joint flows of the ancient Tigris and the Euphrates. Cole and Gasche attempted to identify these fluvial levees with specific ancient fluvial names of the Tigris and the Euphrates and their possible active periods as referred to in various ancient written documents, supplemented with other written, archaeological, and geomorphological evidence, as follows.

7) The dating of the ancient course of the Tigris from the beginning of the 4th millennium BCE to the end of 7th century BCE was determined using a typological classification of pottery shards collected from surfaces of ancient sites as an evaluation criterion [Adams 1965, 126–134].

8) Many scholars have followed Adams's hypothetical reconstruction of the ancient course of the Tigris [Gibson 1972a, 5–7, 13, fns. 56–63, fig. 69; 1972b, 119, map; Nissen 1972, 42; 1976, 20; 1988, 144; Postgate 1976, 77–100; del Monte and Tischlerin 1978, 530; Groneberg 1980, 287–288; Nashef 1983, B III 7; Röllig 1988, B II 7; 1991, B II 8; Roaf 1990; Wall-Romana 1990, 204–245; Finkbeiner and Groneberg 1991, B II 12; Frayne 1992, 41–48, map 4].

Zadok [1978, 304, 332, map; 1985, 361] also supported Adams's view in 1978. However, in 1985, he asserted that the course of the Tigris in the Neo-Babylonian period is uncertain.

9) Geo-referencing here refers to the process of capturing a scanned image of a paper map in GIS and assigning coordinates to it. This allows different maps to be overlaid on each other and given the same set of coordinates, enabling the reading and analysis of geographical features through GIS.

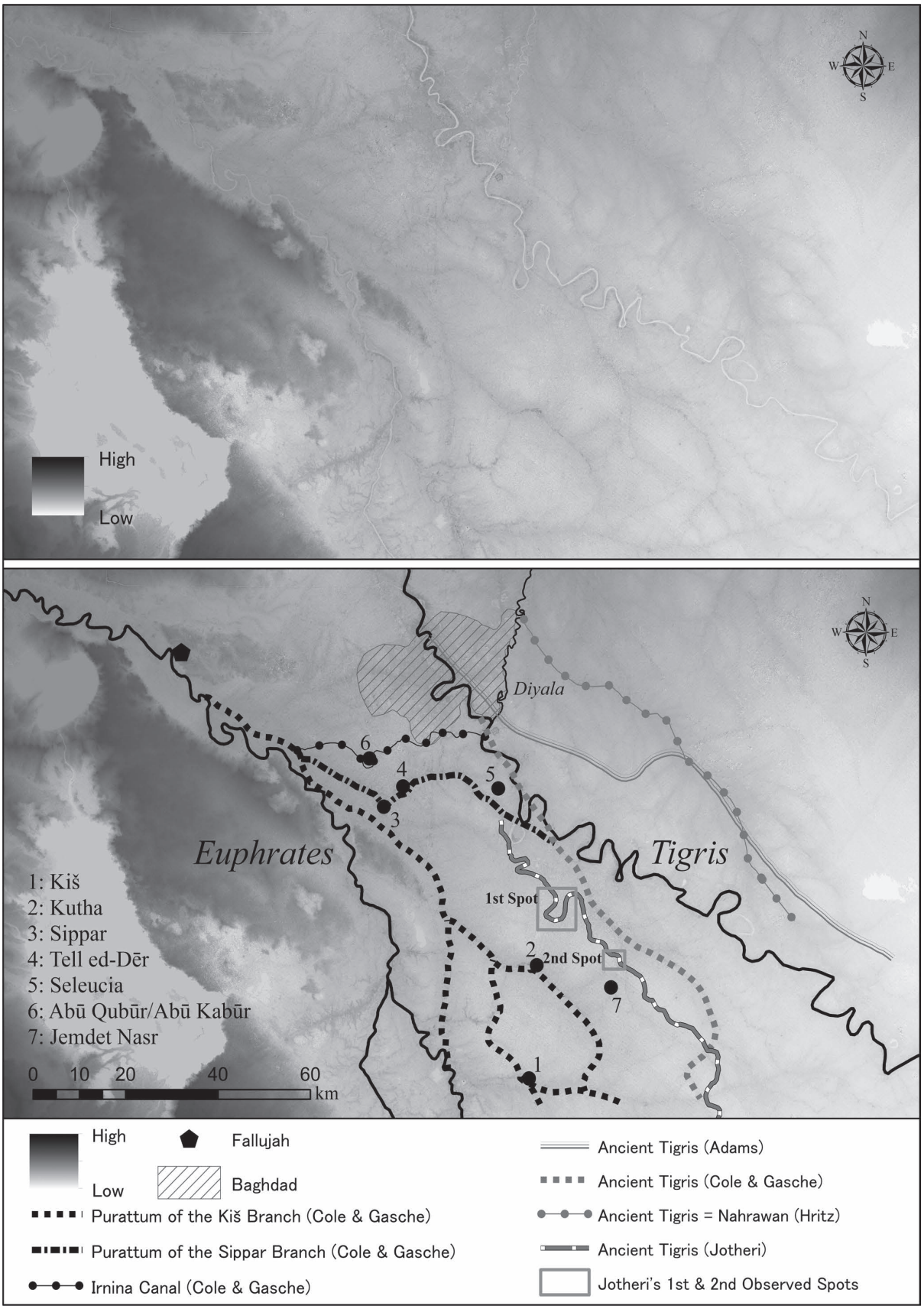


**Fig. 1** SRTM DEM 3D Contour Map of the Northern Part of Southern Mesopotamia without Processing (upper).
**Fig. 2** SRTM DEM 3D Contour Map of the Northern Part of Southern Mesopotamia with Processing (lower).

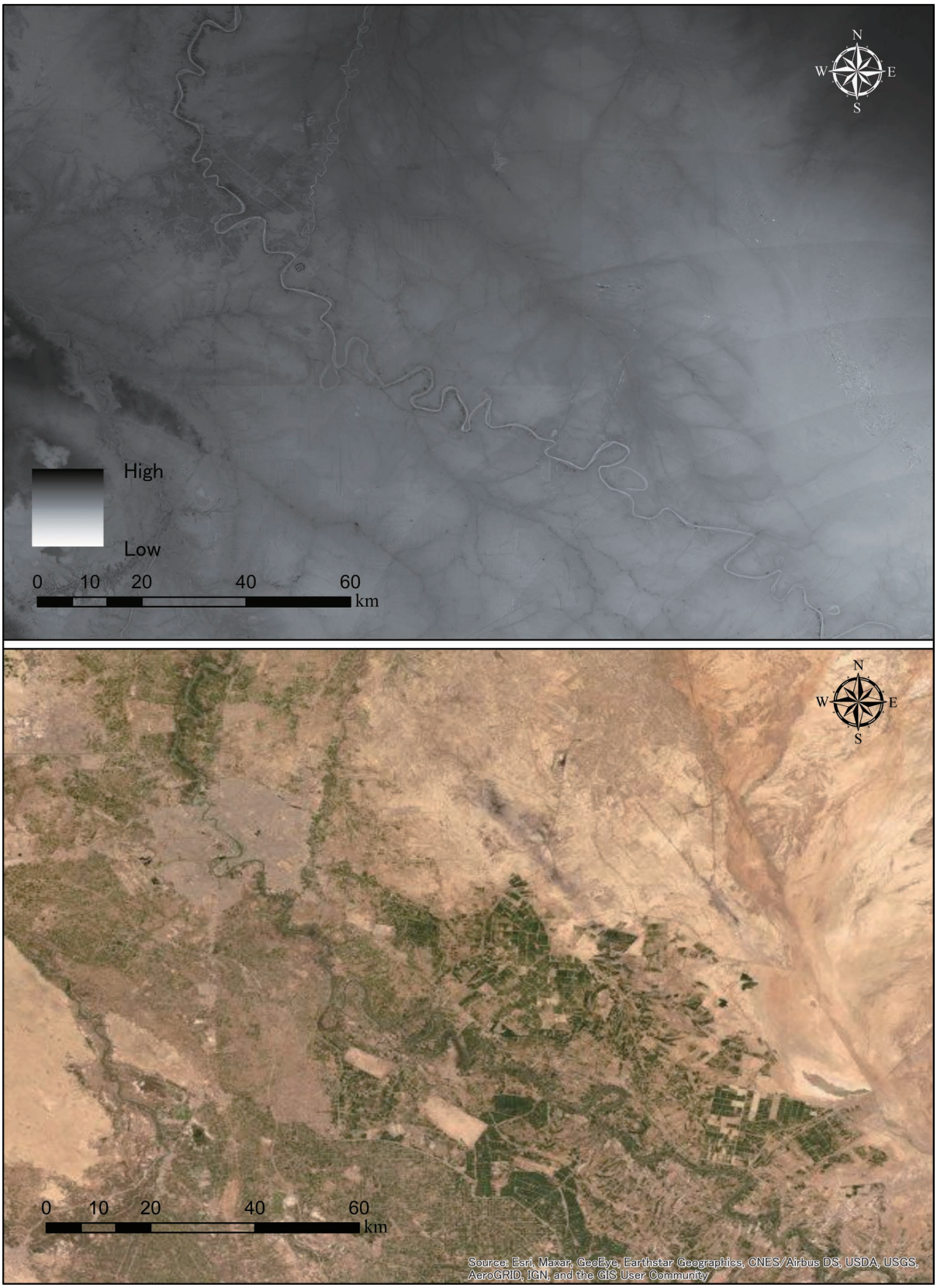


**Fig. 3** ALOS DEM 3D Contour Map of the Northern Part of Southern Mesopotamia (upper).
**Fig. 4** World Imagery Map of the Northern Mesopotamia (lower).

### II.2.1. First Fluvial Levee: *Purattum* of the Kiš Branch

The first fluvial levee of the ancient course of the Euphrates runs from the southeast of Fallujah toward the west of Sippar. It further branches off toward Kiš and Kutha [Cole and Gasche 1998, 25–26]. Cole and Gasche identified this first levee with the ancient Akkadian name of the Euphrates, *Purattum*, because a royal inscription of Naram-Sin of the dynasty of Akkad and the 24th year name of Samsu-iluna of the first dynasty of Babylon refer to Kiš as being located on a bank of the *Purattum* [Edzard, Farber, and Sollberger 1977, 208–209; Groneberg 1980, 303–305; Cole and Gasche 1998, 25–26, fn. 119]. Accordingly, they argued that this first levee was active from the Old Akkadian to the Old Babylonian periods. This first fluvial levee of the ancient course of the Euphrates was reconstructed as black dotted lines on the SRTM DEM 3D contour map (Fig. 2) and is clearly discernible on the SRTM and ALOS DEM 3D contour maps (Figs. 1 and 3, respectively). This implies a possible identification.

### II.2.2. Second Fluvial Levee: *Purattum* of the Sippar Branch and ÍD.UD.KIB.NUN.KI

The second fluvial levee branches off at a point 20 kilometers northwest of Sippar and runs southeast to Sippar and Tell ed-Dēr. From there, it curves gently to the southeast. It eventually joins the present course of the Tigris to the southeast of Seleucia. These researchers inferred that the ancient course of the Tigris must have generally been in the same course as the present course of the Tigris, from the north of Seleucia to its southeast, joining the second levee of the Euphrates to the southeast of Seleucia[10]. On their 3D contour map, Cole and Gasche also found a large and wide fluvial levee running from the southeast of the confluence of the second levee with the present course of the Tigris further to the southeast, to the west of the present course of the Tigris. Thus, they inferred that this large and wide levee must have been created by joint flows of the ancient courses of the Tigris and the Euphrates from the second levee[11].

Written sources from the first half of the 2nd millennium BCE discovered in Mari, further upstream, offer two distinct written ancient names for the Euphrates: the Akkadian name *Purattum* and the Sumerian logographic name ÍD.UD.KIB.NUN.KI (= literally, the Sippar River or Canal). Cole and Gasche [1998, 23–25, 41–52, maps; Groneberg 1980, 303] identified this second fluvial levee with *Purattum* of the Sippar branch and ÍD.UD.KIB.NUN.KI. They also demonstrated the historical existence of the confluence of the ancient courses of the Tigris and the Euphrates in the southeast of Seleucia based on an Old Babylonian document found in Sippar, YOS 12, 469: 4, which describes the field of a *nadītu* (= celibate priestess) in or near a fortress of Puš, bordered by both the Euphrates and the Tigris [Cole and Gasche 1998, 17, fn. 71; 1999, 96–97, fn. 25; 2001, 199–200, fn. 12].

McG. Gibson [1972a, 5–6, 13, fns. 56–58, fig. 69; 1972b, 119, map] presented an account of YOS 12, 469: 4 in the context of an investigation of the ancient course of the Zubi canal and read two registered fluvial names given as bordering the field as ÍD.UD.KIB.NUN.KI (= the

10) Drawing on geological evidence, R. Paepe [1971, 20–27] was the first to note the possibility that the ancient course of the Tigris could have been to the west of its present course. Paepe found a levee of the ancient course of the Tigris in an investigation of the geology of the region around Sippar and Tell ed-Dēr. However, he was only able to give a vague date for it, broadly, after the early Holocene.

Later, Adams [1981, 15–16, 158] conducted geological investigation in the same region and reached the same conclusion as Paepe. He argued that the ancient course of the Tigris appears to have been present until the 4th millennium BCE. However, he did not present concrete evidence to support this view.

11) J. Pournelle [2003, 146–154; Hritz 2010, 193–195] studied this large and wide fluvial levee using Corona satellite photographs, Aster Terra satellite imagery, derived DEMs, and Adams's survey data. Seeking to assign a date to this large and wide levee in relation to the dates of ancient sites situated on its banks, she found that the levee conflates two separate channel systems from two different periods, from the early to middle Uruk periods and from the 2nd to the 1st millennia BCE. Thus, it could have been created during these periods by both the Tigris and the Euphrates together or either the Tigris or the Euphrates separately.

Euphrates) and ÍD.ZUBI (= the Zubi canal). Steinkeller [1980, 26–27] in an investigation of the location of the ancient city of Urum also referred to in this document, read the latter logographic sign as ZUBI[12]. However, according to Cole and Gasche [1998, 17, fn. 71; 1999, 96–97, fn. 25; 2001, 199–200, fn. 12], U. Kasten, curator of the Yale Babylonian collection, collated the latter logographic sign with the original tablet of YOS 12, 469, YBC 6816 to find that the sign in question is not ZUBI but the Sumerian logographic name of the Tigris, IDIGNA.

Cole and Gasche argued that the description of YOS 12, 469: 4 fits with the geomorphological relief of the region southeast of Seleucia, and this supports the assertion of the historical confluence of the Tigris and the Euphrates in this region. They also noted that this supports the view that the ancient course of the Tigris was the same as its present course from the north of Seleucia to its southeast in the first half of the 2nd millennium BCE.

Cole, Gasche, Tanret, and Verhoeven [2002, 537, fns. 19–21, map 1] argued that the active period for *Purattum* of the Sippar branch can be dated further back, to as far as around 3000 to 2500 BCE. They stated that in written sources from the Early Dynastic and Old Akkadian periods, the earlier written form of *Purattum* for the Sippar branch, ÍD.UD.KIB.NUN.KI. (= the Sippar River or Canal) frequently occurs, which means that it was already in existence during these periods. Furthermore, the foundations of Sippar and Tell ed-Dēr can be dated as far back as 3000 BCE, and archaeological investigation confirmed that their foundations were built on the second fluvial levee of the Euphrates[13]. Thus, Cole and others concluded that, considering the margin of error, the historical presence of ÍD.UD.KIB.NUN.KI. can also be dated to at least as far back as 2500 BCE. They also argued that the ancient course of the Tigris could have also flowed generally on its present course and formed a confluence with ÍD.UD.KIB.NUN.KI. (= later *Purattum* of the Sippar branch) in around 2500 BCE[14].

The second fluvial levee of the ancient course of the Euphrates is reconstructed on the SRTM DEM 3D contour map (Fig. 2) as a long and short black dotted line, and it is clearly discernible on the SRTM and ALOS DEM 3D contour maps (Figs. 1 and 3, respectively). It certainly appears to join the present course of the Tigris. The presence of the large and wide fluvial levee running from the southeast of this confluence to further southeast on the west of the present course of the Tigris is also reconstructed on the SRTM DEM 3D contour maps (Figs. 2 and 6) as a grayish dotted line and is again clearly discernible on the SRTM DEM 3D contour maps (Figs. 1 and 5) and the ALOS DEM 3D contour map (Fig. 3). Therefore, the identification that Cole and others proposed also appears possible.

### II.2.3. Third Fluvial Levee: Irnina Canal

The third fluvial meander levee was discerned and reconstructed on their 3D contour map by Cole

12) It should be noted that Steinkeller [1980, 27] incorrectly cited YOS 12, 469 as 468.

13) The Sumerian name for Sippar, zimbir$^{ki}$ is attested in two Sumerian lexical texts, P498157 and P499154, registered in Cuneiform Digital Library Initiative (CDLI). They are dated to the Early Dynastic I-II periods (2900–2600 BCE). Therefore, Sippar's historical presence must date to at least that time.

14) Steinkeller [2005, 32–33] provided support for Cole and others' view that the ancient course of the Tigris was located on its present course and to its west. He took into account an unpublished tablet from the Neo-Babylonian period discovered in Sippar. According to Steinkeller, the tablet records the location of a residential area in the vicinity of the former course of the Tigris, written as ÍD.IDIGINA *labiri*. Therefore, he argued that before the Neo-Babylonian period, the Tigris could have flowed in the vicinity of Sippar, to the west of its present course.

Jotheri [2016, 68] points out that V. M. A. Heyvaert and C. Baetman [2008, 2401–2410] confirmed Cole and others' argument based on the integration of geological, historical, and archaeological data. In tandem with the Belgian-Iraqi excavations of the 1970s, geological boreholes were carried out in the surroundings of Tell ed-Dēr and Sippar. However, these were only partly explored. They used a database of those 225 unpublished geological borehole descriptions with the coupling of archaeological and textual data and identified that the channel activity of ÍD.UD.KIB.NUN.KI. (= later *Purattum* of the Sippar branch) started at least 3100 BCE before the foundation of Sippar. This continued until 1400 to 1000 BCE in the area between Tell ed-Dēr and Sippar.

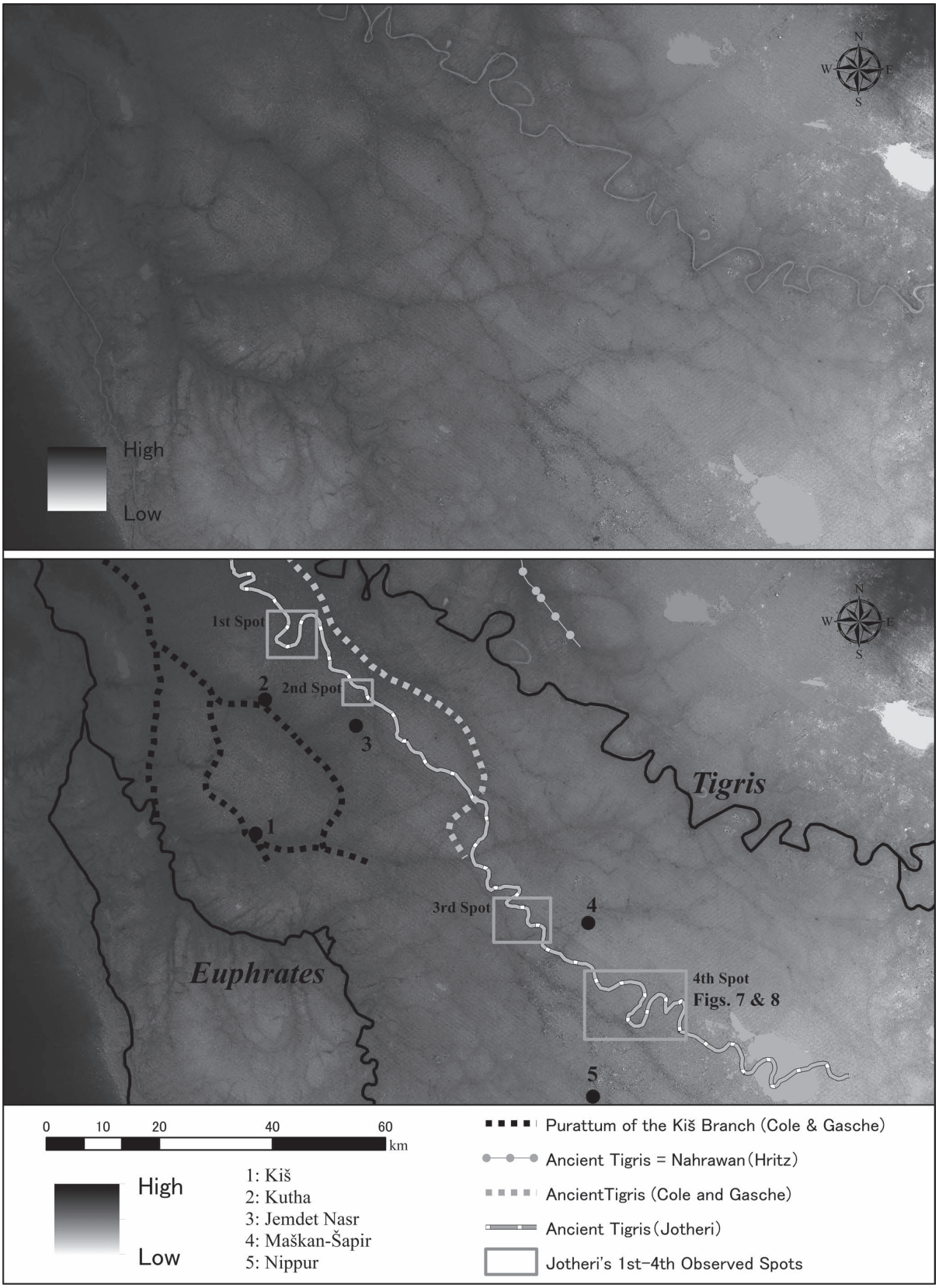


**Fig. 5** SRTM DEM 3D Contour Map of the Central Part of Southern Mesopotamia without Processing (upper).
**Fig. 6** SRTM DEM 3D Contour Map of the Central Part of Southern Mesopotamia with Processing (lower).

and Gasche [1998, 18, 41–52, maps] to branch off a few kilometers upstream, at a point where the second fluvial levee branches off, and then it curved east as far as the ancient site of Abū Qubūr/Abū Kabūr. They further indicated that from Abū Qubūr/Abū Kabūr, it continued to run east and eventually joined a fluvial levee of the ancient course of the Tigris near its present course at a point a few kilometers south of the confluence of the Diyala in an urban district of Baghdad.

Cole and others [1998, 16–23, 41–52; 2001, 200–201; 2002, 540–541, maps 1–2] identified the region around this confluence with the damaged and unreadable toponym of God Sin, referred to in two Old Babylonian tablet copies of the Cadastre of Ur-Nammu, founder of the Ur III dynasty, published by F. R. Kraus [1955, 46–47]. In this text, the damaged toponym is bordered by the Irnina and Zubi canals and is above Puš. According to Cole and others, an Old Babylonian document CT 52, 3: 11–12, found in Sippar refers to Puš, and an Ur III document TCL 5, 6041, states that Puš was located near Sippar[15]. Therefore, they argued that Puš was in the vicinity of Sippar.

Moreover, as shown above the Old Babylonian document found in Sippar, YOS 12, 469: 4, places the field of the *nadītu* (= celibate priestess) in or near the fortress of Puš, bordered by the Euphrates (= ÍD.UD.KIB.NUN.KI = later *Purattum* of the Sippar branch) and the Tigris (= IDIGNA). Cole and others thus identified this field with the region to the southeast of Seleucia. In the Cadastre of Ur-Nammu, the lost toponym was placed above Puš, so it can accordingly be placed above the region of the southeast of Seleucia.

Cole and Gasche [1998, 17–18, fn. 75] also indicated that the Zubi canal, which bordered the lost toponym of the Cadastre, is identifiable as a synonym for the Tigris on the basis of the following pieces of written evidence. The Cadastre places the toponym Ḫibarītum on a bank of the Zubi canal, whereas in a document of the Kassite period, PBS 1/2, 15: 14–5 (= UM 1/2, 15), Ḫibarītum is located on a bank of the Tigris[16]. In the Practical Vocabulary of Aššur, the Zubi canal (= ÍD.ZUBI) is equated with the restored Akkadian name of the Tigris, *di*-[*ig-lat*][17]. In the Neo-Assyrian lexical text Erimḫuš, CT 19, 02, K 04256, found in Nineveh, the Zubi canal is equated with another ancient designation of the Tigris, namely, ÍD.ḪAL.ḪAL.LA[18].

From these observations, Cole and others identified the third fluvial levee of the ancient course of the Euphrates with the Irnina canal. Then they identified the lost toponym of God Sin in the

15) C. B. E. Walker [1976, no. 3] published the original Old Babylonian document, CT 52, 3, and Kraus [1977, 4–5] translated it.

Steinkeller [1980, 26–27] first pointed out the presence of the Ur III document TCL 5, 6041 in his search for the location of the ancient city of Urum. According to Steinkeller, this document indicates that 418 soldiers or workers of the fortress of Puš were under the supervision of a ruler of Sippar, which suggests that Puš must have also been under the control of Sippar, and the two must have been located near each other.

16) Kraus [1955, 46–47] had already pointed out this contradiction. He cited the lexical reference of A. Deimel [1928, 114–115, 60*], in which Deimel had observed that the cuneiform sign of the Zubi might have been either confused with or mistaken for the cuneiform sign for the Tigris. Thus, Kraus [1955, 63] suggested that the Zubi canal may have flowed for a great distance parallel to the Tigris or might have been one of several ancient names for the Tigris. However, Heimpel [2014–2016, 24–25] has recently denied the possibility that the similar sign ZUBI was a variant of the sign IDIGNA.

17) This equation in the Practical Vocabulary of Aššur was first noted by W. W. Hallo [1964, 68, fns. 19–25; Gelb, Landberger, and Oppenheim 1961, 13b–14a; Landsberger and Gurney 1957–1958, 333, 739].

Hallo's [1964, 57–88] views on the relationship between the Zubi canal of the Cadastre of Ur-Nammu and the Tigris and their ancient courses were based on his studies on geographical information of the Old Babylonian Itinerary, which lists the travel stations from Larsa in Babylonia to Emar in Syria; it appears that he considered the Zubi canal to have been a tributary of the Tigris that linearly connected Samarra and Baghdad, or it may have been the name of the main ancient course of the Tigris, initially curving eastward and then running toward Baghdad, like the present course of the Tigris.

18) Regarding the equation of the Zubi canal with ÍD.ḪAL.ḪAL.LA, see Cavigneaux, Güterbock, Roth, and Ferber [1985, 90 rev. iii 11'–13'], Heimpel [2014–2016: 25–28], Bagg [2014–2016, 28–30]. Its photo is registered with CDLI no. P385942, and its transliteration and translation are also registered and searchable under its museum registration no. K 04256 in The Open Richly Annotated Cuneiform Corpus (http://oracc.museum.upenn.edu/dcclt/corpus).

ÍD.ḪAL.ḪAL.LA is equated with the Tigris in the Neo-Assyrian lexical text found in Nineveh, CT 19, 25, K 14042 (= incorrectly published as K 14047). It is registered in CDLI with CDLI no. P385942.

Cadastre, bordered by the Irnina canal and the Zubi canal, with a region bordered by the confluence of the third fluvial levee of the ancient course of the Euphrates with the fluvial levee of the ancient course of the Tigris near its present course at a point a few kilometers south of the confluence of the Diyala, in an urban district of Baghdad[19]. They inferred that from the north of Baghdad to the southeast, the Tigris must have been on its present course as far southeast as Seleucia in the Ur III period[20].

The third fluvial levee of the ancient course of the Euphrates is reconstructed on the SRTM DEM 3D contour map (Fig. 2) as a black line of circular dots. However, the meander levee is undiscernible on the SRTM DEM 3D contour map (Fig. 1), the ALOS DEM 3D contour map (Fig. 3), the World Imagery Map (Fig. 4), and the Corona satellite photographs, as well as on their own 3D contour map. The argument given for the equation of the Zubi canal with the Tigris remains possible. However, the identification of the third fluvial levee of the ancient course of the Euphrates with the Irnina canal cannot be fully supported because no corresponding fluvial levee is discernible. Accordingly, the identification of the lost toponym of God Sin of the Cadastre with the region near the present course of the Tigris at a point a few kilometers south of the confluence of the Diyala with the present course of the Tigris in an urban district of Baghdad cannot be fully supported.

Thus, following the arguments of Cole and others, the ancient course of the Tigris can be reconstructed along its present course only from the north of Seleucia to the southeast, to the west of its present course after 2500 BCE, provided that their identification of the large and wide fluvial levee found southeast of Seleucia with the fluvial levee of the joint flows of the ancient Tigris and Euphrates is correct.

### II.3. Reconstruction by C. Hritz

Hritz [2010, 184–202; 2014, 259–262] puts forward another hypothesis, which, like Adams's, placed the ancient course of the Tigris to the east of its present course. She was the first scholar to use SRTM DEM data with GIS to discern a levee of the ancient course of the Tigris in the northern part of southern Mesopotamia. She based her thinking on the belief that all of the ancient meander

19) As mentioned above, Jacobsen [1960, 175–176, fn. 4] followed Adams's [1957a, 139–141; 1957b, 270–273; 1958, 101–103, figs. 1–6] view that the ancient course of the Tigris must have flowed to the east of its present course. Thus, based on his studies of the meander levees of the fluvial network and geographical information on the Zubi canal and other ancient canals recorded in surviving written sources, he tentatively reconstructed the ancient course of the Zubi canal. He identified the Zubi canal with a fluvial meander levee left in the vicinity of Abū Qubūr/Abū Kabūr, north of Sippar, running toward the southeast of Tell ed-Dēr as an early-branching and most easterly flowing tributary of the ancient course of the Euphrates in southern Mesopotamia. He further inferred that it may have continued to run as far as the east of Jemdet Nasr and Abu Salabikh. Jacobsen was then followed by Gibson [1972a, 5–6, 13, fns. 56–58, 69; 1972b, 119, map] and Adams [1981, 159].

F. Carroué [1991, 130–132] found that the lost toponym of God Sin referred to in the Cadastre may be identified with the city of Urum, and Urum may be also identified with Tell Uqair, located northeast of Kutha and northwest of Jemdet Nasr. This was substantially the same view as Jacobsen's.

Frayne [1992, 12–17, map 4] also followed a series of earlier views. In the same year, G. Farber and W. Röllig [1992, B II 9] made distribution maps of ancient sites in the Old Akkadian and Ur III periods on which the ancient course of the Zubi canal was depicted. No specific explanation was given for the course depicted on the map, but it is consistent with these earlier conclusions as to the ancient course of the canal.

In comparing these views about the identification and the ancient course of the Zubi canal with the SRTM DEM 3D contour map (Fig. 1), the ALOS DEM 3D contour map (Fig. 3), the World Imagery Map (Fig. 4), and the Corona satellite photographs, no fluvial meander levee can be discerned running from Tell ed-Dēr to an area where Jemdet Nasr, Abu Salabikh, and Tell Uqair are located. Therefore, the views of Jacobsen and others are obviously questionable.

As a further supplement, J. Bauer [1972, 284–286, fn. III2] suggested that there was another canal named Zubi in the lower part of southern Mesopotamia that had no relation to the Zubi canal of the northern part of southern Mesopotamia.

20) In the Cadastre, the toponyms Namzium and Ḫirītum appear in close association with both the Irnina and Zubi canals. Cole and Gasche [1998, 18–23, 41–52, maps] argued that they are tentatively identifiable in the vicinity of a region near the present course of the Tigris at a point a few kilometers south of the confluence of the Diyala in an urban district of Baghdad. Thus, they suggested that their localizations strengthened their view of the historical location of the lost toponym of God Sin of the Cadastre as well as the ancient course of the Tigris in the given region.

levees of the fluvial network evident to the west of the present course of the Tigris in the south of Baghdad were left by ancient courses of the Euphrates. For this reason, she rejected the contention that the historical course of the Tigris was the same as its present course or that it was to the west of the present course, as asserted by Cole and others.

Instead, she argued that another levee of the ancient fluvial course to the east of the present course of the Tigris indicates the ancient course of the Tigris. As indicated with a grayish line of circular dots on the SRTM DEM 3D contour map (Fig. 2) and as is clearly discernible on the SRTM DEM 3D contour map (Fig. 1) and the ALOS DEM 3D contour map (Fig. 3), a levee of the ancient course of the Nahrawan canal of the Sassanid Persian period, with an approximately 1-kilometer width and 3-meter-high levees, branches off from the present course of the Diyala River to the east of Baghdad and runs as far as the diversion point of the Gharrāf Canal from the present course of the Tigris. Hritz [2010, 195–202] analyzed differences in the altitude of this course and identified the presence of another ancient fluvial levee with the 2-kilometer width and the 4-meter-high levees left under the levee of the ancient course of the Nahrawan canal with GIS. She pointed out that the levee of this ancient fluvial course runs for a longer distance than the Nahrawan canal and resembles the present course of the Tigris, meandering in a similar way.

To understand the possible active period of this meander levee, Hritz analyzed the positional relationship between it and ancient sites lying along its banks. She geo-referenced Adams's [1965] distribution maps of the ancient sites of the Land Behind Baghdad Survey located to the east of the present courses of the Tigris and the Diyala with a 3D contour map drawn from SRTM DEM data using GIS. She found that ancient sites from the 5th millennium BCE to the second half of the 3rd millennium BCE lie along banks of this levee. She concluded that this meander levee lying under the levee of the course of the Nahrawan canal must have been active during the same period, drying up until the levee was reutilized as the Nahrawan canal during the Sassanid Persian period. On the assumption that all meander levees of the fluvial network remaining to the west of the present course of the Tigris were ancient courses of the Euphrates, she concluded that the meander levee below that of the Nahrawan canal represents the ancient course of the Tigris and must have been active from the 5th millennium BCE to the second half of the 3rd millennium BCE to the east of the present course of the Tigris.

Boreholes were recently drilled in the Nahrawan region to obtain sedimentary samples for analyses by a team of 13 researchers, including Hritz, and their analyses indicated the possibility that the Nahrawan could have been a part of the ancient Tigris before it became a canal [Altaweel *et al*. 2019, 23–24, 32–33]. The sediment was analyzed for its structure, petrography, mineralogy, and microfossil remains, and absolute dates were obtained using accelerator mass spectrometry (AMS) where possible[21]. As a result, it became clear that the pattern of its channel and floodplain deposit indicates contributions from the Tigris and Diyala in about a 2:1 ratio between about 10500 and 5200 BCE. These dates are older than the 5th millennium BCE, so the possibility of the continuous existence of the ancient courses of the Tigris in the Nahrawan region after the 5th millennium BCE was not established.

Using GIS analyses, we observe that two factors make Hritz's reconstruction of the ancient course of the Tigris inconclusive. The first is that, using our SRTM DEM and ALOS DEM 3D contour maps to judge the reconstruction, it is not possible to find any fluvial meander levee

21) To perform radiocarbon dating, it is necessary to determine the amount of radiocarbon in a sample. This measurement can be performed either by measuring the radioactivity of the sample or by directly counting the radiocarbon atoms in AMS. Measuring the radioactivity of the sample works very well if the sample is large; however, less than 0.01% radiocarbon ions decay within 9 months. Thus, within a reasonable measurement time (typically a few weeks), only a very small proportion of radiocarbon atoms can be detected with this method. In principle, AMS can detect a much higher proportion (typically about 1% of the total), allowing sample sizes to be about 1000 times smaller (https://c14.arch.ox.ac.uk/ams.html).

connecting what Hritz assigns as the northern end of the fluvial levee of the ancient course of the Tigris with either the present course of the Tigris or any fluvial levee that can be identified with that of the ancient course of the Tigris in the upper reach region. The second factor relates to her dating of its ancient course. The possible active period for the fluvial levee of the ancient course of the Tigris was assessed by Hritz as falling from the 5th millennium BCE to the second half of the 3rd millennium BCE. However, she does not indicate where the ancient course of the Tigris flowed after this period. Without giving satisfactory explanations of these two factors, her reconstruction of the ancient course of the Tigris cannot be supported.

### II.4. Reconstruction by J. Jotheri

Jotheri [2016, 151–156, figs. 4.29–4.35] argues that a string of four fragmentary fluvial meander levees of the ancient course of the Tigris can be identified to the south of Baghdad in four separately observed spots with the aid of QuickBird satellite images[22]. Therefore, he considers that this ancient course of the Tigris ran to the west of the present Tigris course from the south of Baghdad, passing several important sites by running to the east of Jemdet Nasr, to the west of Maškan-Šapir, east of Nippur, and to the east of Adab, subsequently disappearing under the sediments of the present Gharrāf Canal. He geo-referenced Adams's [1981] distribution maps of ancient sites of southern Mesopotamia and, in association with ancient sites aligned along a meander line connecting those four fragmentary fluvial meander levees, he dated this tentatively reconstructed ancient course of the Tigris from the mid-Holocene to the early 2nd millennium BCE.

He agrees with Cole and Gasche that this course of the Tigris was joined by the ancient course of the Euphrates (= *Purattum* of the Sippar branch = ÍD.UD.KIB.NUN.KI) south of Baghdad. However, he identifies this course as different from the large and wide fluvial levee of the ancient course that runs from southeast of Seleucia to the west of the present course of the Tigris, which Cole and Gasche identified as the levee of the joint flows of the Tigris and Euphrates's ancient courses. Like Hritz, he indicates that the levees of the fluvial network visible on the 3D contour map of SRTM DEM data in the region south of Baghdad are all those of the Euphrates (= *Purattum* of the Sippar branch = ÍD.UD.KIB.NUN.KI) from the period beginning from the late 1st millennium BCE. Jotheri, in fact, determined that the associated ancient sites geo-referenced from Adams's [1981] distribution maps of southern Mesopotamia along those levees of the fluvial network date to this period.

For the ancient course of the Tigris after the early 2nd millennium BCE, Jotheri [2016, 156–157, fig. 4.36] argues that the earlier course had changed its trajectory to become the present course of the Tigris. He considers that the present course of the Tigris would then have formed when the earlier course of the Tigris broke away south of Baghdad, presumably starting as a canal from the earlier main course and then becoming the main course itself.

His reconstruction of the ancient course of the Tigris is geo-referenced and recreated on the SRTM DEM 3D contour map (Fig. 2) with the first and second observed spots (his figs. 4.32–4.33) and on the SRTM DEM 3D contour map (Fig. 6) with first to fourth spots (his figs. 4.32–4.35), where Jotheri claims to have found fragmentary fluvial meander levees of the ancient course of the Tigris on QuickBird satellite images[23]. The four fragmentary fluvial meander levees identified by Jotheri are clearly discernible in the satellite image from World Imagery as well. Those levees certainly resemble the present course of the Tigris. Therefore, they appear to have belonged to the

22) For Quickbird, see https://www.arcgis.com/home/item.html?id=10df2279f9684e4a9f6a7f08febac2a9. It has very high resolution, with 61 centimeters for panchromatic data.

23) Jotheri's third observed spot is mistakenly designated in his fig. 4.31, where no fragmentary fluvial meander levee is discernible. He provides its accurate coordinates, 45°5'45".98"E and 32°24'28.69"N, which suggest that it is located at a point further south-southeast, see Fig. 6.

ancient course of the Tigris. However, no fluvial meander levees are discernible in the tentatively reconstructed ancient course connecting those four fragmentary fluvial meander levees on our SRTM DEM and ALOS DEM 3D contour maps, the satellite image from World Imagery, or the Corona satellite photographs.

Jotheri's dating method has a noticeable failing. He does not give a clear reason for his dating of the earlier course of the Tigris from the mid-Holocene to the early 2nd millennium BCE or of the later course from the early 2nd millennium BCE to the present. He notes that he geo-referenced Adams's [1981] distribution maps of ancient sites in southern Mesopotamia and used these to date the earlier and later courses of the Tigris. He classified and divided all of the ancient sites into only two groups, namely, sites dated from the 4th millennium BCE and sites dated from the late 1st millennium BCE. He only established that ancient sites dating back to the 4th millennium BC are aligned along the identified earlier course of the Tigris, and the ones dating back to the late 1st millennium BCE are aligned along the present course. We could not recreate how he determined the date for the change of the earlier course to the present course during the early 2nd millennium BCE. Using his method, we can only determine the date for the change of the earlier course to the present course in the late 1st millennium BCE, simply because he classified and divided ancient sites into only two groups[24].

Boreholes were also drilled in the Dalmaj region just south of Baghdad to the west of the present course of the Tigris to obtain sedimentary samples for analyses by the same team of 13 researchers, which also included Jotheri as well as Hritz. The sediment of the Dalmaj region was analyzed in the same way as the sediment of the Nahrawan region, and absolute dates were obtained using AMS where possible [Altaweel *et al*. 2019, 23–24, 32–33]. Thus, it became clear that forward compositional modeling indicates equal contributions of the Euphrates and Tigris Rivers in the formation of Dalmaj sediment in the pre-Ubaid to Uruk period. Hence, the possibility of the continuous existence of the ancient course of the Tigris after the Uruk period was not established.

The fourth observed spot where Jotheri claimed to identify the fragmentary fluvial mender levee of the ancient course of the Tigris was reinvestigated by this article's author, and it was found that the fragmentary levee was likely from the Uruk period [Kawakami 2021, in press]. Comparative verification in GIS ascertains that the fragmentary levee discerned by Jotheri on the fourth observed spot is identical with a levee of an ancient watercourse earlier identified and reconstructed by Adams [1981, 56, 64–65, figs. 9, 12–14, map] from analyses of aerial photographs and field surveys. As discerned in the World Imagery Map (Fig. 7) and recreated on the SRTM DEM 3D contour map (Fig. 8), Adams identified a large number of ancient sites lying along the fragmentary fluvial meander levee left in the fourth observed spot, and he dated them to the Uruk period based on the typological analyses of pottery shards collected from their surface remnants; accordingly, he gave this fragmentary levee with the same date[25].

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24) Jotheri [2016, fig. 4.31] notes that Adams's [1981] distribution maps of ancient sites of southern Mesopotamia were used for the dating of the ancient and present courses of the Tigris and the levees of the fluvial network visible on the 3D contour map of SRTM DEM data in the region south of Baghdad. However, the distribution conditions of the ancient sites do not appear to be reflections of Adams's distribution maps of the ancient sites of southern Mesopotamia published in 1981. In the region to the north of Nippur, Adams and V. Crawford separately surveyed the distribution conditions and active periods of ancient sites in 1956–1957 and later published their distribution maps [Adams 1972, 182–28, map 1, maps 1A–1F].

Moreover, only 282 out of the 1567 ancient sites identified from aerial photographs and spotted on the distribution maps were actually visited and dated on the basis of typological analyses of pottery shards collected from their surface remnants. All 282 of these sites were overlaid on the SRTM and ALOS DEM 3D contour maps, and their distribution patterns were analyzed in relation to the fluvial levees of the ancient watercourses that are discernible in the north of Nippur. However, 282 was an insufficient number to obtain any useful results. Therefore, it is unclear where Jotheri takes the information for dates and distribution conditions of ancient sites given in his fig. 4.31. We suppose that he must have relied on the distribution maps of ancient sites and their information published in Arabic by Directorate General of Antiquities, Republic of Iraq [1970; 1976].

25) Figs. 7 and 8 are quoted from the author of this article's previous work [Kawakami 2021, in press, figs. 6.1–6.2].

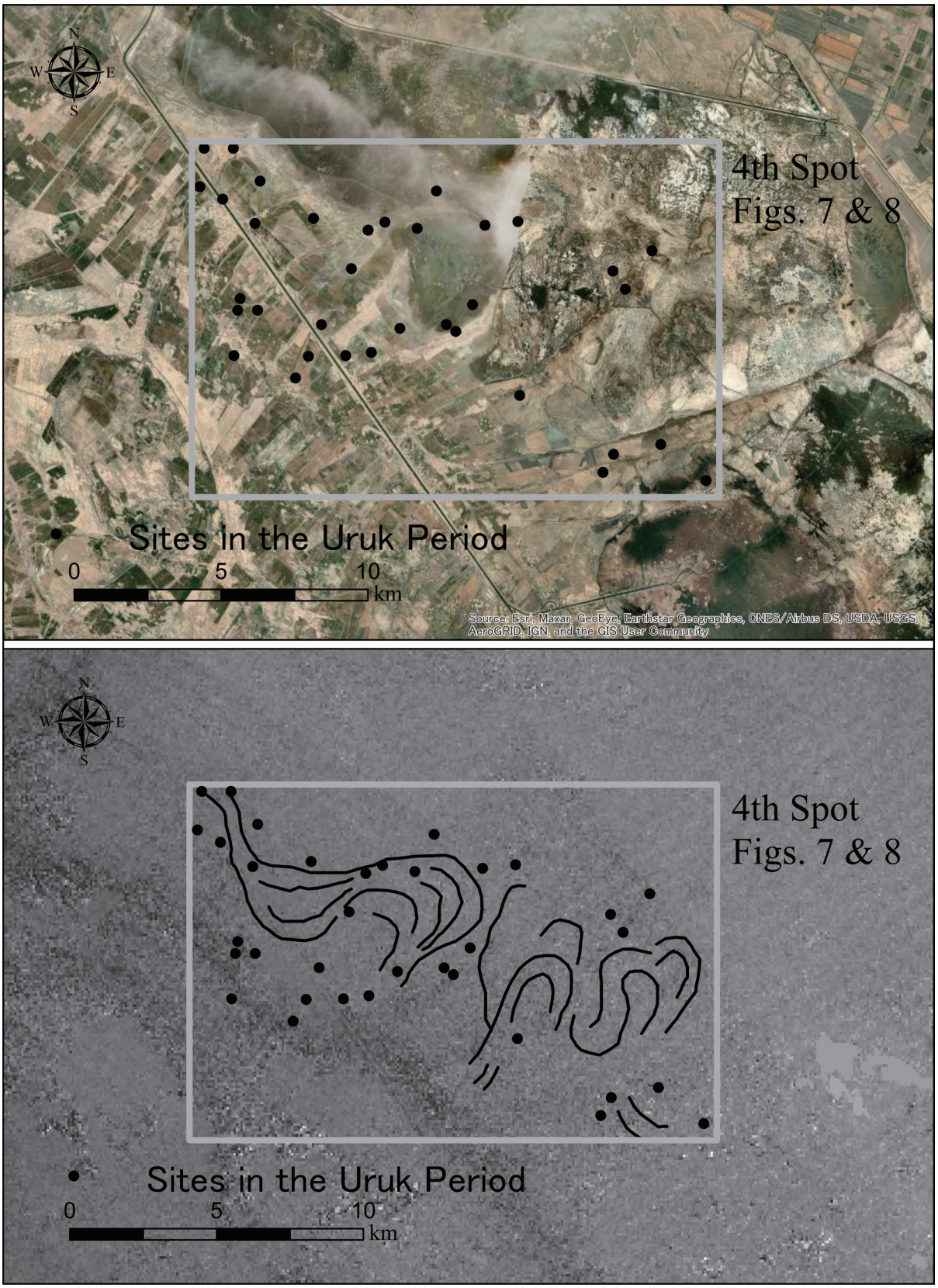


**Fig. 7** World Imagery Map of Jotheri's Fourth Observed Spot with Processing (upper).
**Fig. 8** SRTM DEM 3D Contour Map of Jotheri's Fourth Observed Spot with Processing (lower).

From Jotheri's reconstruction of the ancient course of the Tigris, his dating is certainly problematic. He identifies four fragmentary fluvial meander levees that appear to belong to the ancient course of the Tigris, but from borehole analyses, they appear to have belonged to the Uruk period, and the associated ancient sites on the fourth observed spot only accord with this date.

## III. Positional Relationship with the Ancient Course of the Tigris Further to the Southeast

Further to the southeast in the southern part of southern Mesopotamia, historical geographical analyses were made by Biggs [1965, 95–102], Heimpel [1990, 204–213], and Steinkeller [2001, 22–84] to reconstruct the ancient course of the Tigris. Biggs's study of a letter from the Kassite period indicated that the Tigris may have flowed in the eastern vicinity of Nippur, west of its present course. In Heimpel's study on the documents of the Ur III period and later in Steinkeller's study of a large number of the documents of the same period found in Umma to reconstruct a route of riverine transportation of goods from Umma and/or its surrounding areas through KA-saḫar to Nippur and/or Esagdana, it has been presumed that the ancient course of the Tigris during this period extended from a point in the north-northwestern vicinity of Umma to Karkar and Adab in the further northwest, and then to a point 20–25 kilometers north-northwest of Nippur, west of its present course in the northern and central parts of Sumer in the southern part of southern Mesopotamia. Three documents given by Steinkeller are particularly important: *ASJ* 8: 68–69: i 3–4, MVN 15 94: iii 7–8, and Sigrist Yale 1452: 1–5[26]. In association with many other documents of the Ur III period found from Umma, the former two confirm the historical presence of the ancient course of the Tigris in the vicinity of Umma, Karkara, and probably Adab, and the latter confirms its historical presence in the vicinity of Nippur and Esagdana (= Puzriš-Dagan) [Steinkeller 2001, 33–34; Kawakami 2021, in press].

The majority of their views were reconfirmed by this article's author, who as mentioned above, employed the same GIS analyses as described in this article to discern the presence of an actual fluvial levee of the ancient course of the Tigris on the SRTM DEM and ALOS DEM 3D contour maps, satellite imagery from World Imagery, and Corona satellite photographs of the southern part of southern Mesopotamia, comparing it with the views of Biggs, Heimpel, and Steinkeller [Kawakami 2021, in press]. These previous research results are summarized here to indicate and verify which ancient course of the Tigris, as reconstructed by Adams, Cole and others, Hritz, and Jotheri in the northern part of southern Mesopotamia enables it to be joined to the ancient course of the Tigris in the region of its lower reaches in the southern part of southern Mesopotamia.

On the SRTM DEM 3D contour maps (Figs. 9 and 10), the region from Umma to Nippur and the further north are shown[27]. Fig. 9 presents the SRTM DEM 3D contour map without any processing. Fig. 10 is the processed SRTM DEM 3D contour map, on which both the present watercourses and the fluvial levees of ancient watercourses are traced and highlighted.

In Fig. 9, a fluvial levee of an ancient watercourse is clearly discernible at a location that is almost coincident with the ancient course of the Tigris, which Steinkeller, from the topographical information contained in the documents of the Ur III period, presumed that it extends from a point in the north-northwestern vicinity of Umma to Karkar and Adab in the further northwest and then to a point north-northwest of Nippur. The presence of the consistent fluvial levee is also discernible on the ALOS DEM 3D contour map. As indicated in Fig. 10 by a black and white line, the fluvial levee of this ancient watercourse extends for about 100 kilometers from a point 10 kilometers to the north-northwest of Umma through Karkar and Adab to a point 30 kilometers north-northwest of

26) The abbreviations of these three texts are as per Steinkeller [2001, 22].

27) Fig. 9 is also quoted from fig. 2 of the author of this article's previous work, whereas Fig. 10 is a modified version of fig. 3 [Kawakami 2021, in press, figs. 2–3].

Nippur. The fluvial levee is particularly clear from a point 9 kilometers southeast of Adab to a point 30 kilometers north-northwest of Nippur. This fluvial levee is up to 2 kilometers wide, as measured by GIS. Therefore, the fluvial levee of this ancient watercourse can likely be identified with that of the ancient course of the Tigris, as Steinkeller concluded.

In addition, it is discernible on the SRTM DEM 3D contour map (Fig. 9) and on the ALOS DEM 3D contour map that the fluvial levee of this ancient watercourse, which extends from the north-northwestern vicinity of Umma to the north-northwest of Nippur, diverges in the direction of Nippur from a point 30 kilometers north-northwest of Nippur, as is also reconstructed in the form of a black dotted line on the SRTM DEM 3D contour map (Fig. 10). It then passes through the eastern vicinity of Nippur and rejoins the main stream near Adab.

Comparative analyses were conducted to clarify the positional relationship between the fluvial levee of the ancient course of the Tigris, discerned on the SRTM DEM 3D contour map (Fig. 9) and the ALOS DEM 3D contour map with the distribution conditions of the ancient sites of the Ur III period [Kawakami 2021, in press]. Adams's [1981] distribution maps of ancient sites in the northern and central parts of Sumer were also used. These maps were geo-referenced using GIS, and only ancient sites dated to the Ur III period were overlaid on the SRTM and ALOS DEM 3D contour maps. Thus, it was found that the ancient sites of this period were distributed along the fluvial levee of the ancient course of the Tigris, as observed on the SRTM DEM 3D contour map (Fig. 11), on which ancient sites are overlaid that date back to the Ur III period[28]. This certainly demonstrates that the fluvial levee of the ancient course of the Tigris was the only major watercourse active in the northern and central parts of Sumer in the southern part of southern Mesopotamia during the Ur III period that could support habitation at that time in this region, and the surrounding land was irrigated with a number of canals from this watercourse.

In an area to the northeast of Nippur, a cross-section of the fluvial levee of the ancient course of the Tigris was investigated by Gibson and T. J. Wilkinson in 1990 [Wilkinson, Rayne, and Jotheri 2015, 406–409; Wilkinson and Jotheri in press]. Furthermore, at a point slightly to the southeast of the area northeast of Nippur that was investigated by Gibson and Wilkinson, a borehole survey was carried out by Jotheri [2016, 104–105]. It proved possible to discern that the course of the Tigris diverges toward Nippur from a point 30 kilometers to the north-northwest of Nippur. The bifurcated fluvial levee then passes through the eastern vicinity of Nippur and rejoins the fluvial levee of its main stream near Adab. A cross-section of this diverged fluvial levee at a point in the southwestern vicinity of Adab was investigated in 2013, and a borehole survey was also later carried out at the same point by Jotheri [2016, 104–105; Wilkinson and Jotheri in press].

Their investigations confirmed that the deposition process of the fluvial levees of the main stream and the tributary of the ancient course of the Tigris began in the later 5th millennium BCE and were continuously active until the first half of the 15th century CE. Therefore, the results of Gibson and Wilkinson's and Jotheri's investigations are additional confirmation that the fluvial levees of the main stream and tributary of the ancient course of the Tigris, discerned on the SRTM DEM 3D contour map (Fig. 9) and the ALOS DEM 3D contour map were definitively active in the northern and central parts of Sumer in the southern part of southern Mesopotamia during the Ur III period [Kawakami 2021, in press].

Looking further north than the location 30 kilometers to the north-northwest of Nippur, a number of fluvial levees of ancient watercourses are discernible on the SRTM DEM 3D contour maps (Figs. 9 and 12) and the ALOS DEM 3D contour map. Two of them join downstream to form the fluvial levee of the ancient course of the Tigris at a point 30 kilometers north-northwest of Nippur. One of them, which runs from the north-northwest, is connected in its upper reach with

28) Fig. 11 is also quoted from the author of this article's previous work [Kawakami 2021, in press, fig. 7].

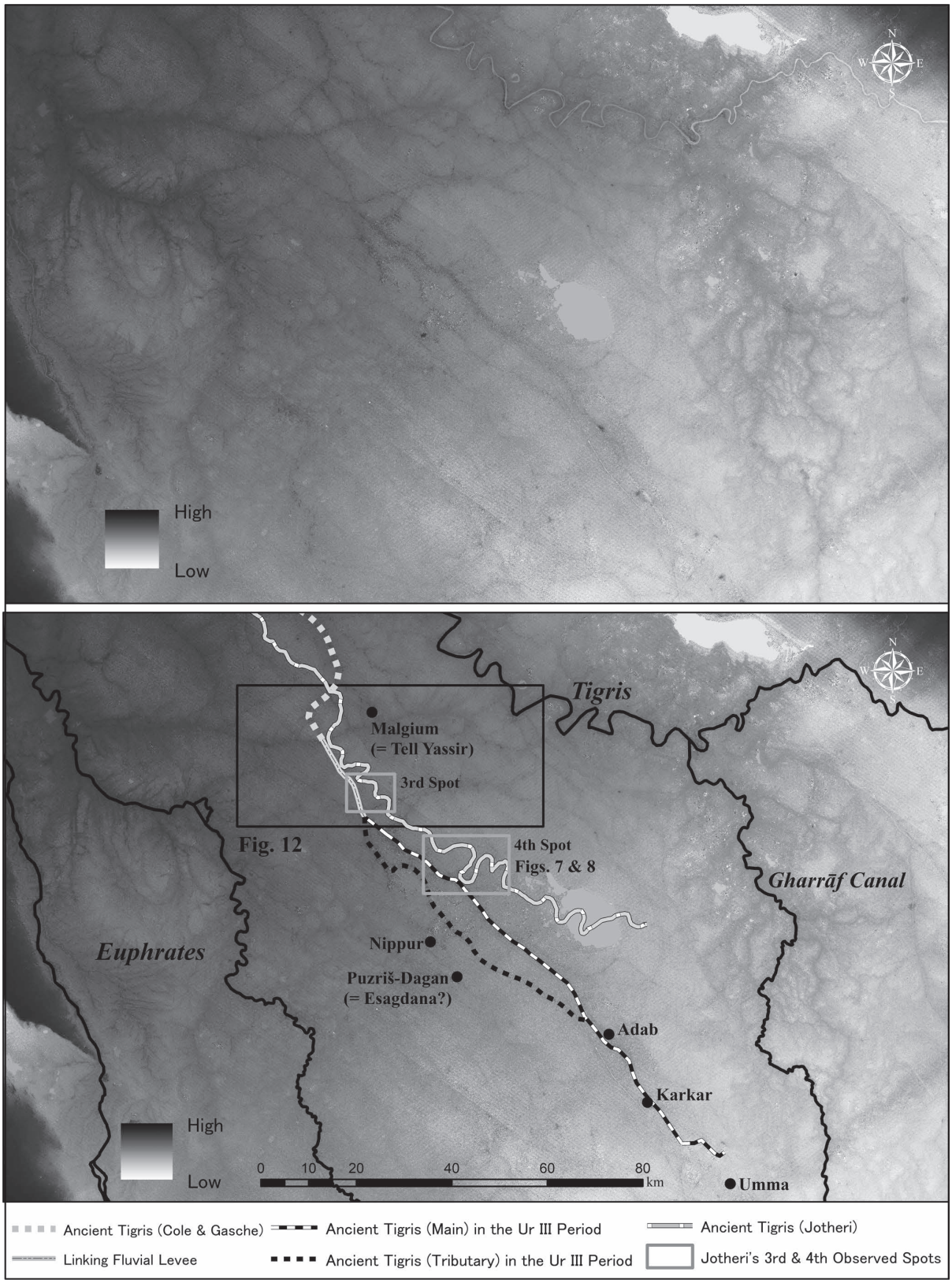


**Fig. 9** SRTM DEM 3D Contour Map of the Southern Part of Southern Mesopotamia without Processing (upper).
**Fig. 10** SRTM DEM 3D Contour Map of the Southern Part of Southern Mesopotamia with Processing (lower).

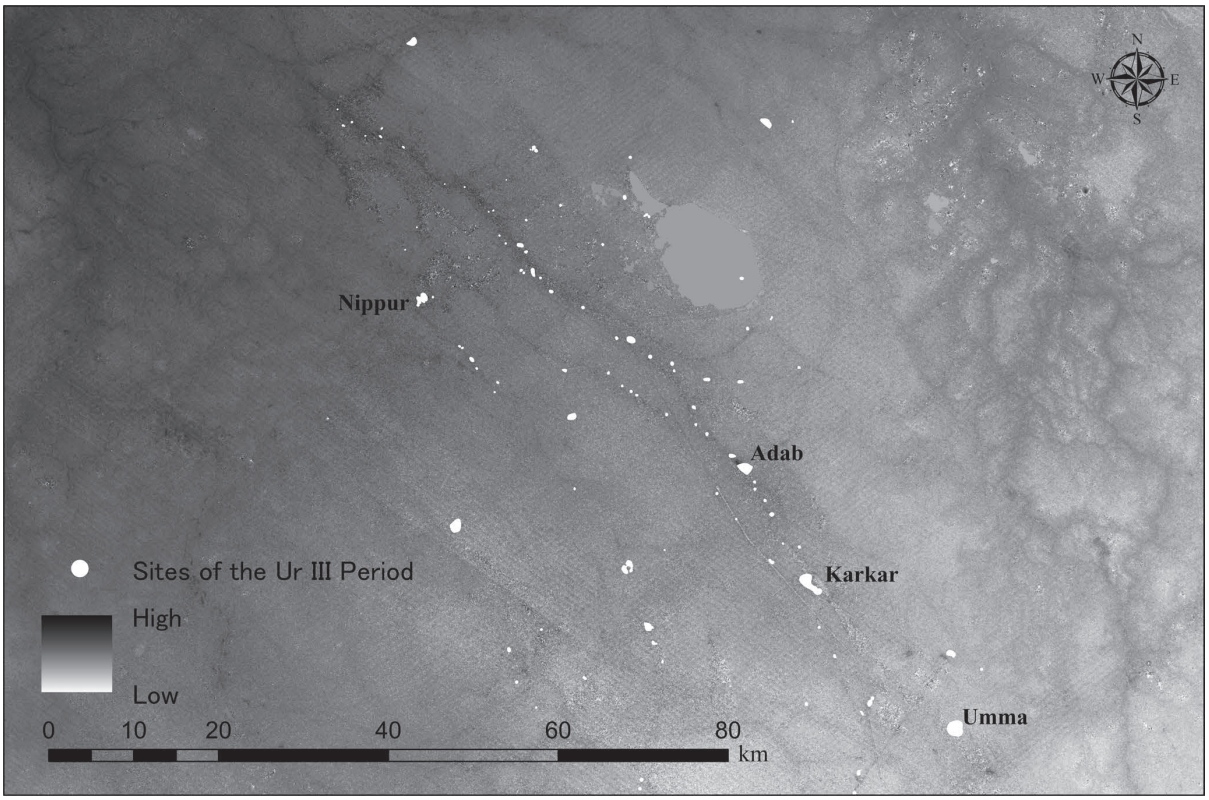


**Fig. 11** SRTM DEM 3D Contour Map with Sites of the Ur III Period.

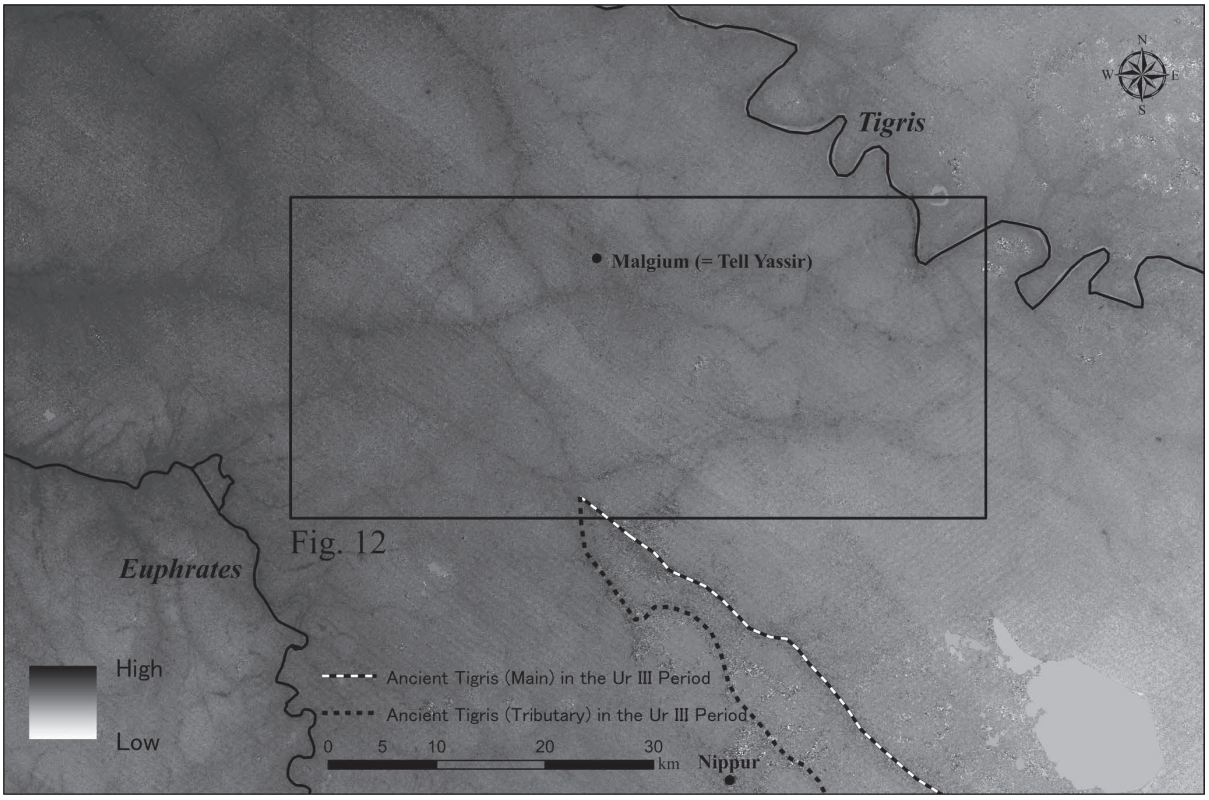


**Fig. 12** SRTM DEM 3D Contour Map in the Vicinity of Malgium.

a large and wide fluvial levee, which Cole and Gasche identified with the joint flows of the Tigris and Euphrates's ancient courses. Cole and Gasche's large and wide fluvial levee is reconstructed as a grayish dotted line and the linking fluvial levee is reconstructed as a grayish line on the SRTM DEM 3D contour map (Fig. 10). This suggests that Cole and Gasche's reconstruction of the ancient course of the Tigris in the northern part of southern Mesopotamia is the most plausible.

However, it is not possible to determine the active periods of this linking fluvial levee and the large and wide fluvial levee of the joint flows of the Tigris and Euphrates's ancient courses identified by Cole and Gasche at a glance only on the SRTM DEM contour maps (Figs. 9 and 12) and the ALOS DEM 3D contour map. Hence, the need to clarify the histories of the depositional processes of these fluvial levees is a pressing concern. If the histories of these fluvial levees are dated back to the Ur III period, this enables us to confirm that they are the fluvial levees of the ancient course of the Tigris in the northern part of southern Mesopotamia. Accordingly, Cole, Gasche, Tanret, and Verhoeven's identification and reconstruction of the ancient course of the Tigris in the same region are certainly supported.

Furthermore, the historical presence of the ancient course of the Tigris at this linking point is confirmed. Malgium was recently identified with Tell Yassir with the discovery of royal inscriptions of early Old Babylonian kings of Malgium [Jawad *et al*. 2020, 65–86]. Royal inscriptions of the Ur III kings Šulgi and Šu-Suen were also discovered at the site, confirming that it was occupied before the end of the 3rd millennium BCE. Most importantly, its location in the vicinity of the ancient course of the Tigris was historically confirmed in a royal inscription clearly stating that the great wall of Malgium on the banks of the Tigris was destroyed. Its location is visible in the SRTM DEM 3D contour maps (Figs. 10 and 12) on the eastern bank of the ancient courses of the Tigris, as reconstructed by Cole and Gasche as well as Jotheri. Thus, in historical terms, Cole, Gasche, Tanret, and Verhoeven's and Jotheri's reconstructions of the ancient course of the Tigris are consistent, whereas Adams's and Hritz's reconstructions are not possible.

## IV. Conclusion

The validity of four reconstructions of the ancient course of the Tigris proposed by Adams, Cole, Gasche, Tanret and Verhoeven, Hritz, and Jotheri in and around Baghdad and to its south in the northern part of southern Mesopotamia is verifiable using GIS analyses with the aid of SRTM DEM and ALOS DEM 3D contour maps, satellite imagery from World Imagery, and Corona satellite photographs. Adams established a possible ancient course of the Tigris to the east of its present course on the latitude between the north of Baghdad and the diversion point of the Gharrāf Canal from the present course of the Tigris from the beginning of the 4th millennium BCE until the Neo-Babylonian period, around the end of the 7th century BCE, afterward changing its flow in a westward direction to its present course. No fluvial levee that corresponds to Adams's reconstruction was found in the GIS analyses. Therefore, his reconstruction is inconclusive.

Cole, Gasche, Tanret, and Verhoeven proposed to reconstruct the ancient course of the Tigris from the north of Baghdad along its present course as far as the southeast of Seleucia and then to the further southeast, west of its present course from 2500 BCE until the first half of the 2nd millennium BCE. They demonstrated that the two tributaries of the Euphrates, the Irnina canal and ÍD.UD.KIB.NUN.KI. (= later *Purattum* of the Sippar branch) joined the ancient course of the Tigris. They proposed that the former joined at a point a few kilometers south of the confluence of the Diyala in an urban district of Baghdad, and the latter at a point southeast of Seleucia. Our GIS analyses did not identify the physical presence of any fluvial levee of the Irnina canal on their reconstructed line but could clearly establish the fluvial levee of ÍD.UD.KIB.NUN.KI. (= later *Purattum* of the Sippar branch) and its confluence with the present course of the Tigris southeast

of Seleucia. Cole and Gasche also found a large and wide fluvial levee running southeast of the confluence of ÍD.UD.KIB.NUN.KI. (= later *Purattum* of the Sippar branch) with the present course of the Tigris, west of its present course. They inferred that this was likely created by joint flows of the ancient courses of the Tigris and Euphrates. This fluvial levee was also discerned in our analyses. Thus, their reconstruction of the ancient course of the Tigris appeared obviously plausible, apart from their reconstruction of the Irnina canal.

Hritz reconstructed the ancient course of the Tigris to the east of its present course under the levee of the course of the Nahrawan canal and dated it from the 5th millennium BCE to the second half of the 3rd millennium BCE. No fluvial meander levee connecting the northern end of the ancient course of the Tigris was reconstructed by Hritz in either its present course or any fluvial levee of the ancient course of the Tigris in its upper reach region. Moreover, she did not demonstrate the whereabouts of its course after the second half of the 3rd millennium BCE. Considering these factors, her reconstruction of the ancient course of the Tigris is not convincing.

Jotheri argued that the ancient course of the Tigris must have flowed from the south of Baghdad, west of the present course of the Tigris, to further south from the mid-Holocene to the early 2nd millennium BCE; subsequently, after the early 2nd millennium BCE, the earlier course changed trajectory and became the present course of the Tigris. Jotheri found four fragmentary fluvial meander levees resembling its present course in four separately observed spots south of Baghdad. Those fragmentary levees are clearly discerned on the satellite imagery from World Imagery by our GIS analyses. However, no fluvial meander levee was discernible under his tentatively lined ancient course connecting these four fragmentary fluvial meander levees. Additionally, no fluvial meander levee connecting the northern end of Jotheri's tentatively reconstructed ancient course of the Tigris with either its present course or any fluvial levee of the ancient course of the Tigris in its upper reach region were evident. Unfortunately, his dating of the reconstructed earlier and later ancient courses of the Tigris is problematic and cannot be supported. The four fragmentary fluvial meander levees identified resemble its present course. Thus, they appear to belong to the ancient course of the Tigris. However, the borehole analyses and the associated ancient sites on the fourth observed spot indicated that those four fragmentary fluvial meander levees belong to the much earlier Uruk period. These factors make his reconstruction of the ancient course of the Tigris inconclusive.

Thus, only Cole, Gasche, Tanret, and Verhoeven's reconstruction of the ancient course of the Tigris along its present course is ultimately the most plausible candidate. Moreover, their reconstruction can be directly connected to its present course upward in the region of its upper reach.

Finally, the locations of the four reconstructions of the ancient course of the Tigris proposed by Adams, Cole and others, Hritz, and Jotheri were compared with their southeastern counterpart in the southern part of southern Mesopotamia. From Steinkeller's study of a large number of the documents of the Ur III period found from Umma, it was presumed that the ancient course of the Tigris during this period extended from a point in the north-northwestern vicinity of Umma to Karkar and Adab in the further northwest and then to the north-northwest of Nippur, west of its present course. This author's previous study reconfirmed most of Steinkeller's view and identified the physical presence of the fluvial levee corresponding Steinkeller's presumed ancient course of the Tigris in the Ur III period. A linking fluvial levee that connects the northwestern end of the fluvial levee of the ancient course of the Tigris of the Ur III period in the south with the southeastern end of the large and wide fluvial levee of the joint flows of the ancient courses of the Tigris and Euphrates, as identified by Cole and Gasche, was discerned by our GIS analyses. Moreover, the historical presence of the ancient course of the Tigris in this linking point was confirmed with the recently identified location of Malgium with Tell Yassir with the discovery of the royal inscription of the early Old Babylonian king of Malgium, stating its location in the vicinity of the ancient course of the Tigris.

Ultimately, we made clear that Adams's and Hritz's reconstructions, which place the ancient course of the Tigris to the east of its present course, are not in accord with the location of the ancient course of the Tigris in the southern part of southern Mesopotamia and in the vicinity of Malgium. Thus, their views cannot be supported. Instead, the location of the ancient course of the Tigris in the south was found to be consistent with Cole and others' and Jotheri's reconstructions of the ancient course of the Tigris in the north.

In conclusion, having comprehensively considered each perspective, Cole, Gasche, Tanret, and Verhoeven's reconstruction of the ancient course of the Tigris in the northern part of southern Mesopotamia seems to be the most plausible. To further confirm the whereabouts of the location of the ancient course of the Tigris in this region, two things must be determined, namely, (1) the dates of the large and wide fluvial meander levee that runs to the southeast of the ancient site of Seleucia— identified by Cole and Gasche—with the joint flows of the Tigris and Euphrates's ancient courses and (2) the linking fluvial levee that connects the former with the ancient course of the Tigris in the Ur III period—presumed by Steinkeller—along with its physical presence in the southern part of southern Mesopotamia—reconfirmed by this article's author. If both fluvial levees can be dated back to the Ur III period, this would verify the correctness of Cole and others' reconstruction of the ancient course of the Tigris. If the dates cannot be established to the Ur III period, the majority of fluvial levees of the ancient course of the Tigris in the northern part of southern Mesopotamia must have varied and erased as suggested by Jotheri; accordingly, only four fragmentary fluvial meander levees could be identified in the four observed spots. Therefore, this indicates that its fluvial levees are no longer discernible in GIS analysis.

As noted above, Huritz, Jotheri, and others have conducted sediment investigations of the levees of the ancient courses of the Tigris in the Nahrawann and Dalmaj regions and analyzed sediment to identify active periods [Altaweel *et al*. 2019, 23–24, 32–33]. The same investigation was also carried out on the levees of the ancient course of the Euphrates [Jotheri *et al*. 2017, 1–13; Jotheri, Allen, and Wilkinson 2015, 1–19]. If this type of investigation were to be performed across the large and wide fluvial meander levee of the joint flows of the ancient course of the Tigris and Euphrates identified by Cole and Gasche and the linking fluvial levee that joins the former with the ancient course of the Tigris of the Ur III period in the region of the lower reach, a more accurate identification and reconstruction of the ancient course of the Tigris would be possible in this region.

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