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DATING THE *TIWANAKU* STATE[1]

ANÁLISIS CRONOLÓGICO DEL ESTADO TIWANAKU

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The number of radiocarbon dates associated with the Tiwanaku state has grown through the years, and there are more than 130 published ^{14}C determinations. In this paper radiocarbon dates from different regions of the Tiwanaku culture area were collected, described, calibrated and analyzed. The results have been compared with existing chronological frameworks and various existing theories on the nature and development of the Tiwanaku state. Calibrated sets of ^{14}C dates and their related cultural contexts show that phases Tiwanaku I, II and III overlap; and that Tiwanaku IV and V partially overlap. Calibration of sets, combined with geographical origin show the main period of Tiwanaku activity falling under the second half of the first millennium, but differences are found in particular areas of influence.

Key words: ^{14}C, radiocarbon dating, calibration, cumulative calibration, chronology, Tiwanaku.

Los fechados radiocarbónicos del Estado de Tiwanaku han aumentado en los últimos años a más de 130 fechas. En este trabajo se discuten, analizan y se calibraron las fechas radiocarbónicas recopiladas de la literatura para diferentes regiones de Tiwanaku. Las fechas fueron comparadas con los diferentes marcos cronológicos propuestos para esta Cultura y su desarrollo cultural. Las fechas radiocarbónicas calibradas asociadas a contextos culturales muestra que hay un traslape entre las fases Tiwanaku I, II y III y sólo un traslape parcial con Tiwanaku IV y V. Las calibraciones de los fechados analizados según su origen geográfico demuestra que el período principal de Tiwanaku cae bajo la mitad del primer milenio, pero habrían algunas diferencias cronológicas de acuerdo al área de influencia.

***Palabras claves**: fechados radiocarbónicos, fechados calibrados cumulativos, cronología, Tiwanaku.*

During the Middle Horizon (ca. A.D. 500-1000) the Tiwanaku culture and supposed empire dominated the entire area of the south central Andes including: Titicaca Lake basin, northern Chilean valleys, Cochabamba, Moquegua valley, and into the San Pedro de Atacama oasis to the Southwest. More than 360,000 km^2 (Ponce Sangines 1980:8) were under the influence and in some cases direct power of the Tiwanaku rulers (Berenguer 1978; Browman 1981; Byrne Caballero 1984; Higueras 1996; Kolata 1993a, 1993b; Núnez 1965; Owen 1992, 1994; Ponce Sangines 1981; Torres 1987; Wassen 1972).

Tiwanaku influence appeared in different regions in diverse forms. The results of excavations and experiments conducted in the 80s and 90s by Alan Kolata at Tiwanaku and Pampa Koani suggested that an application of intensive agricultural strategies was a very important factor for Tiwanaku development. This was the assumed base for power and export of ideology by a centralized, bureaucratic Tiwanaku state in Alan Kolata's model (Kolata 1986, 1991, 1993a, 1996). More recent research has shown, that Tiwanaku could have had a more elastic and agglutinated nature; it could have consisted of semi-autonomous regions which were included within the state web, but with preexisting settlement patterns and hierarchy (the model of nested hierarchies by Albarracin-Jordan 1996). Critics of the centralized vision of the Tiwanaku state also have pointed out that probably even its efficient agricultural strategies were not so temporally and socially expansive (Erickson 1988; Graffam 1992), as it was suggested earlier. In some parts of the Tiwanaku area of influence, i.e. in the Moquegua valley, there is ample evidence for a metropolis - province relationship. In Moquegua, were found administrative centers, with temples, state architecture, etc. In other regions the interactions with Tiwanaku were not so clear and it has been more appropriate to describe them in terms of economic and ritual patterns of exchange (Higueras 1996). This is the case for Northern Chilean valleys, Cochabamba valleys and the oasis of

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San Pedro de Atacama (Kolata 1993b). Thus, the time in which certain forms emerged would be important indicators of the Tiwanaku culture and state archaeological reconstruction.

For more than 100 years research has focused on the art, economy, and chronology of Tiwanaku. The first reliable publication on the topic of chronology was produced by Max Uhle. Based on the ceramic sequence from Pachacamac, Max Uhle established chronology of five periods, with main units of Tiwanaku (classic and epigonic) and Inca (Uhle 1903). In the mid 1930s, after the excavations at Tiwanaku in 1932, Wendell Bennett presented a ceramic chronology consisting of Early, Classic and Decadent Tiahuanaco (Bennett 1934). For the areas outside Titicaca basin, local imitations of Tiwanaku style ceramics were described as Derived Style (Bennett 1934). The next chronological systematization was proposed by Carlos Ponce Sangines (Ponce Sangines 1969); five epochs division was based on 21 radiocarbon dates, that came mainly from the Tiwanaku site. Although criticized (Browman 1980; Mathews 1995; Albarracin-Jordan 1996), it persisted for a very long time as the most detailed proposition.

The way that radiocarbon evidence was used in constructing this scheme was one of the reasons for questioning it. The principal shortcomings of the five epochs chronology are specified below.

1) ‘Semi-historical’ borders between periods, were difficult to defend, as originally they represented mode values of ^{14}C dates chosen by Ponce Sangines, and it is not clear why certain modes appeared as borders.
2) Data used for the construction of the scheme often did not cover events important for defining periods. Dates which should represent certain epochs were not connected by the context of samples with events that should have appeared at that time. For example, samples for dates that represent epoch III, according to Ponce Sangines this was when the Tiwanaku ceremonial center with its main buildings was erected, were not taken from any of these structures and cannot be related to any of its construction phases (Albarracin-Jordan 1996:40).
3) Definitions of periods were often incongruent with the archaeological data. In recent publications (for example Janusek 1999; Mathews 1995), the relative chronology of ceramic phases was revised. Ponce Sangines’ epochs I and III ceramics represent most probably, according to Mathews, two different functional ceramic types from the same period of time (Mathews 1995:90). It is also possible, that the distinction of ceramic styles Tiwanaku 4 and 5 is related instead to spatial, functional, and/or prestige rather than a temporal difference (Janusek 1999). A new proposal for a general chronology of the Southern Titicaca Basin was presented recently by Janusek (2003).
4) The last, but a very important deficiency: the boundaries between periods, and actually the whole scheme was based on radiocarbon ages. These ones were never converted to absolute time through calibration into calendar years.

Gathering and calibrating the existing radiocarbon dates from Tiwanaku culture contexts was felt to be helpful to: (1) determine time relationships among existing relative chronological periods/stylistic phases, and (2) ameliorate an absolute chronology for Tiwanaku cultural presence in distinct regions. The approach to realize these two goals is presented below.

Application of ^{14}C Method for Determination of Absolute Age

Because of the changing amount of ^{14}C isotope in the atmosphere, results obtained in laboratories should be converted from radiocarbon years into calendar ages. This transformation called calibration is unfortunately not a one-to-one transformation and thus two or more calendar values may correspond to one radiocarbon date. As a consequence of course, the normal probability distribution of radiocarbon age date is divided into exact intervals of calendar age following the calibration curve. The radiocarbon date usefulness for further interpretations depends on several factors including: 1) technical nature (method, time of measurement, type of material), and 2) sample context (and it’s association with certain events and periods of relative chronology).

The main source of Tiwanaku data used in analyses and discussed below was “Radiocarbon database for Bolivia, Ecuador and Peru”, a joint publication of Andean Archaeological Mission of the Institute of Archaeology of Warsaw University and Gliwice Radiocarbon Laboratory of the Institute of Physics of Sileasian Technical University (Ziółkowski et al. 1994). It was also possible to include some new dates thanks to the help of Prof. P.R.Williams (references for dates from Moquegua, based on Dr. B. Owen 1989), Dr. JoEllen Burkholder (dates from Iwawe) (Burkholder 1997), Dr. Matthew Seddon (dates from Isla del Sol) (Seddon 1998), Dr. Alexey Vranich (one date from Puma Punku); and a large set of dates from 15 years at the Wila Jawira Project, which appeared in successive publications (i.e. Kolata 1993, Kolata 1996, 2003; Kolata and Ortloff 1996:51).

This collection consists of more than 130 dates. The first radiocarbon dates to come from Tiwanaku material were made in mid 1950s, and the majority of the dates we have come from publications and citations produced in 50's and 60's (Table 1). The 'old' dates, especially from the 50s and 60s, are not as reliable as those recently measured. Samples collection techniques, their pretreatment, and measurement techniques have all been improved considerably since that time (nowadays measurement of radioactivity usually can give results which accuracy is comparable with those made by AMS (Accelerator Mass Spectrometry) technique Pazdur and Pazdur 1994 in: Ziółkowski et al. 1994). More than one in every five dates gathered here, however, do not mention when they were produced. It was assumed, that the six 'not-fully-described' dates from Chile were probably produced in 1960s or 1970s (according to date of publication by Berenguer 1978). Many dates from Tiwanaku and Lukurmata (Kolata and Ortloff 1996:51) came from the laboratory of Southern Methodist University (SMU), which had been closed in the late 1980s or early 1990s (Ziółkowski et al. 1994; Radiocarbon vol 41 n 31999). Also worth noting, is that nearly half of the dates came from samples that were collected at Tiwanaku site itself. Although newer dates produced in the 1980s and 1990s (mainly from the Wila Jawira Project) represent almost half of collection, they come only from sites in the Moquegua valley and Titicaca basin. The cultural context of all gathered dates is often not described according to Tiwanaku I-V phases. Furthermore, in most cases, sample materials were charcoal, but often references lack any information about sample material.

The set of Tiwanaku radiocarbon dates gathered here is certainly not complete nor is it statistically very large, therefore it is difficult to treat the results presented here as precise answers to above mentioned aims. However, the worth of individual radiocarbon dates can be increased by the use of statistical methods. The method used here was the simple method of cumulative probability calibration. Probabilities of radiocarbon ages were gathered and then calibrated. The obtained interval of highest probability density were correlated with tested events or phases.

Cumulative Calibration

Two methods for dates sets selection were used to analyze the dates: 1) according to geographical and 2) cultural phase contexts of collected samples[2]. In the geographical approach, the main purpose was to determine the calendar age of Tiwanaku influence in different regions. Tiwanaku ^{14}C dates were divided into five main sets (A-E) according to their geographic location (Titicaca lake basin, Northern Chilean valleys, Moquegua valley, and Cochabamba). Dates from Moquegua valley were further divided into sets according to sample phase con-

Table 1. Distribution of ^{14}C dates by time and geographic area.
Distribución de datos ^{14}C por décadas y área geográfica.

Decades/Areas	Not described	'50	'60	'70	'80	'90 +	
Tiwanaku	18	25			3	16	62
Rest of Titicaca basin	6				2	35	43
Northern Moquegua			2		2	8	12
Chile	6	1		4			11
Cochabamba		1	2				3
Total	30	27	4	4	7	59	131

texts, and dates from the Titicaca site were divided according to Janusek's (2003) proposition of general division into Late Formative 1 2, and Tiwanaku periods (Table 2).

A) 98 dates form the set from the Titicaca lake basin. Cultural/stylistic contexts of samples were determined from original publications as Tiwanaku I, II, III, IV, V, Early, Classic, Late Formative 1 or 2, or the dates were related to construction phases of supposed state / ritual architecture. There are 62 dates from samples collected from the Tiwanaku site: fourteen from Kalasasaya, thirteen from Akapana, five from the area "between Akapana and Putuni", four from Kantatayita (Ziółkowski et al. 1994), twelve from Akapana East sector, seven from Putuni, one from Kheri Kala, and one from Puma Punku (A.Vranich, 1999). The location of one sample collected in Tiwanaku site (ETH-5680) was not described - there were only references that the samples cultural context was Tiwanaku V phase (Kolata and Ortloff 1996:51). There were also four other dates from the Tiwanaku site, that were produced from the samples collected at Kalasasaya (P-534, P-GaK-51, GaK-52, GaK-53) (Ziółkowski et al. 1994) that have no descriptions of their cultural contexts and results of dating suggest that samples are not connected with the main period of occupation of the Kalasasaya temple. Perhaps they represented events related to earlier human activities at this site. Nineteen dates came from Lukurmata: two from Misiton I sector (Janusek 1999:117), nine from Ridge sector, four from Misiton II sector 1 from raised field, and two from K'atupata, and one other from an undescribed location (Kolata and Ortloff 2001:51). Four dates were from CK-65 (Kirawi) site in Catari valley. Fourteen dates were from samples that related to use or construction of waru waru platforms. Two dates were from Iwawe - these were obtained from Burkholder (1997), a member of the excavation project at this site. The last four dates come from Isla del Sol, and were included into this analysis thanks to Dr. M. Seddon (1998), a member of the excavation project at Isla del Sol. In accordance with Janusek's (2003) new chronology propositions for the Southern Titicaca basin, additional divisions were made for Late Formative 1-2 set (18 dates, set A1), and a Tiwanaku set (54 dates set A2). Finally dates from waru waru were calibrated together in set A3.

B) The second set consists of four dates related to Tiwanaku presence in the Moquegua valley. One age determination was made on the sample from Omo M 12 site. Omo phase. Three other dates were from Omo, site M 10, from Chen Chen phase stratum (Goldstein 1989).

C) Another set of dates from Moquegua valley is related to what is known as the Tumilaca phase. It is considered to be the post-Tiwanaku, but with Tiwanaku cultural manifestations. It consists of eight dates: two samples collected at Chen Chen, one from Omo, site M 11-1406, five from the sites along the coast of the Moquegua valley. Three of these latter dates are from El Aldogonal site, two others were from Loreto Alto. All five samples came from mixed Ilo-Tumilaca, Ilo-Tumilaca-Cabuza, Chiribaya / Ilo-Tumilaca / Cabuza contexts (Goldstein 1989).

D) Set of dates from Cochabamba consisted of only three dates. Two of these were from the Mizque site (cultural context of sample was described as Tiwanaku IV), and one from the Omereque site (cultural context Tiwanaku V). All the samples were collected from burial contexts. These dates from Cochabamba were produced in the 1950s and 60s. There were also dates of Tiwanaku material from Cochabamba not included in this set. In some cases their standard error was too big and the date only give clues to the antiquity of the sample (i.e. Tx-1550 from Santa Lucia - see Table 2). In other cases (i.e. dates from Cruzpata site submitted by Byrne Caballero), the results produced ages too early for Tiwanaku material in Cochabamba (Tx 1818A - 2320±50 B.P., Tx 1818B 2400±80 B.P.).

E) Six dates from Northern Chile were combined into another set. Two of them come from the Azapa-6 site, two others from Azapa-83 site in Arica. Another date came from a sample collected at the Pica-8 site and another from the Canamo-3 site. There are also four dates for the so called 'miner mummy', from Chuquicamata. The mummy wore clothes with Tiwanaku style motifs and it was found in a

Table 2. Radiocarbon dates from different region of *Tiwanaku* Culture.
Dataciones radiocarbónicas de diferentes regiones de la Cultura Tiwanaku

Laboratory Code	**Radiocarbon age B.P.**	**Calibrated age B.P.**	**Phase**	**Site submited**	**Sample**	**Used in calibration "cultural context" set**	**Used in calibration "geographical" set**
			Northern Chile and San Pedro de Atacama				
LJ-3947	1400±40	625-669	*	Chuquicamata	1979		
LJ-3948	1650±130	250-300 (0.150), 310-550 (.850)	*	Chuquicamata	1979		
LJ-3949	1350±80	630-780	*	Chuquicamata	1979		
LJ-3950	840±150	1040-1290	*	Chuquicamata	1979		
*	1700±150	210-530 (.953)	*	Quitor 6	*		
*	1570±65	420-550	*	Azapa 6	*		E
GaK-5917	1220±80	710-890	*	Azapa 6	*		E
*	1390±110	540-720 (.881), 740-770 (.119)	*	Azapa 83	*		E
GaK-5810	1190±70	770-900 (.849), 920-950 (.151)	*	Azapa 83	*		E
IVIC-792	950±70	1030-1080 (.383), 1080-1260 (.617)	*	Pica 8	*		E
Tk-101	1190±60	770-900 (.897), 920-940 (.103)	*	Canamo 3	*		E
			Cochabamba				
B-449	840±100	1060-1090 (.154), 1120-1140 (.102), 1160-1280 (.744)	Tiwanaku 4	Mizque	1965		D
B-550	930±100	1020-1200 (.954)	Tiwanaku 4	Mizque	1965		D
M-509	900±200	970-1290 (.980)	Tiwanaku 5	Omereque	1955		D
Tx - 1817B	1550±330	120-790 (.970)	Tiwanaku	Santa Lucía	1973		D
			Moquegua				
Beta-51067	830±60	1170-1280	Tumilaca (Chiribaya/ Ilo-Tumilaca/ Cabuza)	El Aldogonal	*		C
Beta-51069	870±60	1050-1090 (.315), 1120-1140 (.124), 1160-1230 (.561)	Tumilaca (IloTumilaca/Cabuza)	Loreto Alto	*		C
Beta-51070	1040±50	960-1030 (.911)	Tumilaca (Ilo-Tumilaca/Cabuza)	Loreto Alto	*		C
Beta-51061	980±60	1000-1070 (.506), 1080-1130 (.328), 1140-1160 (.166)	Tumilaca (Ilo-Tumilaca)	El Aldogonal	*		C
Beta-51065	970±60	1010-1080 (.485), 1080-1130 (.344)	Tumilaca (Ilo-Tumilaca)	El Aldogonal	*		C
Hv-1076	1040±65	900-920 (.142), 940-1040 (.815)	Tumilaca	Chen-Chen	1965		C

Laboratory Code	Radiocarbon age B.P.	Calibrated age B.P.	Phase	Site submited	Sample	Used in calibration "cultural context" set	Used in calibration "geographical" set
Hv-1077	930±65	1030-1160	Tumilaca	Chen-Chen	1965		C
(?) Hv-1080	470±235	1280-1670 (.984)	Loreto (Tiahuanacoid)	Loreto Viejo	*		
(?) Hv-1081	750±60	1220-1290	Loreto (Tiahuanacoid/ Chiribaya?)	Loreto Viejo	1965		
(?) Hv-1091	980±70	100-1070 (.502), 1080-1130 (.384), 1130-1160 (.150)	Loreto (Tiahuanacoid)	Loreto Viejo	1965		
Beta-26649	1170±70	780-900 (.763), 920-960 (.237)	Tumilaca	Omo M11-1406	*		C
Beta-26650	1120±60	880-1000 (.954)	Chen-Chen	Omo M10 - 1758	*		B
Beta-26651	1990±70	57BC - 83 AD (.924)		Omo	*		
ZZZZ-07**	1350+/70-	630-720 (.789), 740-770 (.211)	Omo	Omo M-12	1990		B
ZZZZ-08**	1050±60	900-920 (.166), 950-1030 (.834)	Chen-Chen	Omo M-10	1990		B
ZZZZ-09**	1064±50	900-920 (.220), 960-1020 (.780)	Chen-Chen	Omo M-10	1990		B
			Titicaca basin				
B-488	2400±200	790-360 BC (.931)	Tiwanaku I	Tiwanaku/Kalasasaya	1957	1	A, A1
B-489	2530±200	840-397 BC (.985)	Tiwanaku I	Tiwanaku/Kalasasaya	1957	1	A, A1
GaK - 192	1990±110	120 BC - 130 AD (.945)	Tiwanaku I	Tiwanaku/Kalasasaya	1958	1	A, A1
GaK - 193	1850±90	70-250 (.962)	Tiwanaku I	Tiwanaku/Kalasasaya	1958	1	A, A1
GaK - 194	3530±120	1990 - 1730 BC (.846)	Tiwanaku I	Tiwanaku/Kalasasaya	1958	1	A1
P-532	1653±61	330-440 (.773)	Tiwanaku I	Tiwanaku Kalasasaya	*	1	A, A1
B-490	2100±200	390 BC - 80 AD	Tiwanaku II	Tiwanaku/Kalasasaya	1957	2	A, A1
GaK - 195	1750±100	210 - 410 (.893)	Tiwanaku II	Tiwanaku/Kalasasaya	1958	2	A, A1
Hv- 19	1645±80	340-470 (.724), 490-530 (.229)	Tiwanaku II	Tiwanaku Kalasasaya	1958	2	A, A1
Hv-18	1630±130	320-560 (.877), 260-300 (.123)	Tiwanaku II	Tiwanaku Kalasasaya	1958	2	A, A1
P-533	778±133	1160 - 1310 (.734)	Tiwanaku IV	Tiwanaku Kalasasaya	*	4	A, A2
P-534	1866±62	80-220	*	Tiwanaku Kalasasaya	*		
GaK - 51	630±110	1290-1410	*	Tiwanaku/Kalasasaya	1957		
GaK - 52	2190±130	390 BC - 90 AD (.974)	*	Tiwanaku/Kalasasaya	1957		
GaK - 53	2410±140	760 - 670 BC (.236), 670-600 BC (.163), 600-390 (.601)	*	Tiwanaku/Kalasasaya	1957		
ETH-5639	1090±60	900 – 1000	*	Tiwanaku/Akapana	1988		A
ETH-5640	1090±85	860-1030 (.964)	*	Tiwanaku/Akapana	1988		A
INAH - 972	1120±140	770 - 1030 (.949)	*	Tiwanaku/Akapana	1989		A
P - 119	1460±200	380 - 780 (.984)	*	Tiwanaku/Akapana-Putuni	1955		A
P-146	949±98	1010-1190	*	Tiwanaku/Akapana-Putuni	1955		A
P-147	1576±104	390-600	Tiwanaku Early	Tiwanaku/Akapana-Putuni	1955	3	A, A1

Laboratory Code	Radiocarbon age B.P.	Calibrated age B.P.	Phase	Site submited	Sample	Used in calibration "cultural context" set	Used in calibration "geographical" set
P-149	1707±93	220-430	Tiwanaku Early	Tiwanaku/Akapana-Putuni	1955	3	A, A1
P-150	1692±104	230-440 (.891)	Tiwanaku Early	Tiwanaku/Akapana-Putuni	1955	3	A, A1
P-123	1817±103	110-260 (.691), 280-330 (.234)	Tiwanaku Early	Tiwanaku/Kantatayita	1955	3	A, A1
P-120	1702±103	220-440 (.951)	Tiwanaku Classic	Tiwanaku/Kantatayita	1955	4	A A2
P-120 A	1226±100	690-890	Tiwanaku Classic	Tiwanaku/Kantatayita	1955	4	A A2
P-121	1423±175	420-780	Tiwanaku Classic	Tiwanaku/Kantatayita	1955	4	A A2
***	1510±25	540-600	*	Tiwanaku/Pumapunku	*		A
Beta-55490	1290±100	660-820 (.916)	*	Lukurmata-Misiton I	90'	5	A, A2
Beta-55487	1100±200	760-1060 (.807)	*	Lukurmata-Misiton I	90'	5	A, A2
****	1225±50	720-740 (.147), 770-880 (.853)	*	Iwawe	90'	5	A, A2
****	1025±50	900-910 (.103), 960-1040 (.847)	*	Iwawe	90'	5	A, A2
OS-12671	1420±40	610-660	*	Isla del Sol	90'	5	A, A2
OS-12678	1370±35	640-680	*	Isla del Sol	90'	5	A, A2
OS-12676	1310±40	670-720 (.844)	*	Isla del Sol	90'	5	A, A2
OS-12675	1140±35	880-970	*	Isla del Sol	90'	5	A, A2
SMU-5639	1170±60	780-900 (.810), 920-960 (.190)	*	Tiwanaku/Akapana	*	5	A
ETH-6306	1460±60	550-650	Tiwanaku IV Late	Tiwanaku/Akapana	*	4	A, A2
SMU-2468	1390±50	610-680	Tiwanaku IV Late	Tiwanaku/Akapana	*	4	A, A2
SMU-2165	1000±230	860-1250 (.962)	Tiwanaku V	Lukurmata	*	5	A, A2
ETH-3180	990±95	970-1170	Tiwanaku V	Lukurmata/Ridge	*	5	A, A2
ETH-3179	1180±110	770-970	Tiwanaku V	Lukurmata/Ridge	*	5	A, A2
SMU-1920	1201±96	720-750 (.136), 770-900 (.735), 920-950 (.129)	Tiwanaku V	Lukurmata/Misiton II	*	5	A, A2
SMU-2367	1150±80	850-980 (.723), 810-850 (.222)	Tiwanaku V	Tiwanaku/Akapana	*	5	A A2
SMU-2330	1080±210	770-1160 (.979)	Tiwanaku V	Tiwanaku/Akapana	*	5	A A2
SMU-2276	1070±60	900-920 (.280), 940-1020 (.720)	Tiwanaku V	Tiwanaku/AkEast	*	5	A A2
SMU-2277	1130±60	870-990 (.894)	Tiwanaku V	Tiwanaku/AkEast	*	5	A A2
SMU-2469	1190±100	720-750 (.123), 770-900 (.663), 910-970 (.214)	Tiwanaku V	Tiwanaku/AkEast	*	5	A A2
ETH-5680	1170±65	780-900 (.808), 920-960 (.192)	Tiwanaku V	Tiwanaku	*	5	A A2
SMU-2467	1130±60	870-990 (.894)	Tiwanaku V	Tiwanaku/Putuni	*	5	A A2
SMU-2472	1200±115	760-900 (.643), 710-750 (.162), 920-960 (.158)	Tiwanaku V	Tiwanaku/Putuni	*	5	A A2
SMU-2465	1110±50	890-990	Tiwanaku V	Tiwanaku/Putuni	*	5	A A2
SMU-2466	1170±60	780-900 (.810), 920-960 (.190)	Tiwanaku V	Tiwanaku/Putuni	*	5	A A2
SMU-2289	1185±60	780-900 (.890), 920-950 (.110)	Tiwanaku V	Tiwanaku/AkEast	*	5	A A2

Laboratory Code	Radiocarbon age B.P.	Calibrated age B.P.	Phase	Site submited	Sample	Used in calibration "cultural context" set	Used in calibration "geographical" set
SMU-2290	1120±70	860-1000 (.952)	Tiwanaku V	Tiwanaku/AkEast	*	5	A A2
ETH-3178	1085±90	860-1030 (.935)	Tiwanaku V	Lukurmata/raised field	*	5	A, A2
SMU-2117	1090±60	900-1000	Tiwanaku V	Lukurmata/Misiton II	*	5	A, A2
SMU-2285	1425±211	410-780 (.893)	Tiwanaku V*****	Tiwanaku/Akapana	*		A, A1
SMU-2293	1388±116	540-730 (.857) or 740-770 (.143)	Tiwanaku IV	Tiwanaku/Akapana	*		A A2
SMU-2329	1403±211	430-780 (.858)	Tiwanaku V	Tiwanaku/Akapana	*		A A2
SMU-2336	1243±113	670-890	LTiwanaku IV –	Tiwanaku/Akapana	*		A A2
			E Tiwanaku V				
SMU-2473	850±243	970-1330 (.891)	Tiwanaku V – Pacajes	Tiwanaku/Akapana	*		A A2
OS-11306	1560±25	440-450 (.127) or 460-520 (.751)	LF – Tiwanaku IV	Tiwanaku/Putuni	*		A A2
		or 530-540 (.122)					
SMU-2369	1360±155	540-790 (.826) or 790-840 (.101)	LF – Tiwanaku IV	Tiwanaku/Putuni	*		A A2
OS-10643	1230±40	720-740 (.76) or 770-870 (.824)	Tiwanaku IV – V	Tiwanaku/Putuni	*		A A2
SMU-2333	1716±276	30-610	LF – Tiwanaku IV	Tiwanaku/Akapana East	*		A A2
Beta-55491	1500±100	530-640 (.655) or 460-520 (.295)	LF 1 – L Tiwanaku IV	Tiwanaku/Akapana East	*		A A2
SMU-2332	1017±115	940-1160 (.890) or 900-920 (.110)	Tiwanaku V	Tiwanaku/Akapana East	*		A A2
SMU-2331	872±197	980-1300	Tiwanaku V	Tiwanaku/Akapana East	*		A A2
SMU-2471	1428±99	530-700 (.945)	LF 2 - Tiwanaku IV	Tiwanaku/Akapana East	*		A A2
			LTiwanaku IV –				
SMU-2278	1246±112	680-890	E Tiwanaku V	Tiwanaku/Akapana East	*		A A2
SMU-2470	632±183	1190-1480		Tiwanaku/Akapana E	*		
SMU-2115	1261±210	600-1000	Tiwanaku IV - V	Lukurmata/K'atupata	*		A A2
M-1051	1780±150	80-410	Late Formative 1 – 2	Tiwanaku/Kalasasaya	*		A, A1
M-1050	1760±150	120-430	Late Formative 1 – 2	Tiwanaku/Kalasasaya	*		A, A1
M-1047	1950±150	BC 120-240 AD (.980)	Late Formative 1	Tiwanaku/Kalasasaya	*		A, A1
		1150-1310 (.673) or 1040-1100					
M-1049	780±150	(.164)	Tiwanaku V	Tiwanaku/Kheri Kala	*		A A2
SMU-2164	2100±235	BC 400-130 AD (.977)	LF 1	Lukurmata/Ridge	*		
SMU-2119	1997±70	BC 60-80 AD (.916)	LF 1	Lukurmata/Ridge	*		A
SMU-2116	2004±62	BC 60-70 AD (.952)	LF 1	Lukurmata/Ridge	*		A
SMU-2120	1748±254	20-550 (.972)	LF 1 – 2	Lukurmata/Ridge	*		A
SMU-2118	1619±67	380-540	LF 2	Lukurmata/Ridge	*		A
SMU-3177	1340±95	600-780 (.970)	Late Tiwanaku IV	Lukurmata/Ridge	*		A
			Early Tiwanaku IV / Early				
SMU-2113	1275±218	590-990 (.983)	Tiwanaku V	Lukurmata/Ridge	*		A A2
			Tiwanaku V –				

Laboratory Code	Radiocarbon age B.P.	Calibrated age B.P.	Phase	Site submited	Sample	Used in calibration “cultural context” set	Used in calibration “geographical” set
B-55488	920±70	1030-1170	E. Pacajes	Lukurmata/Misiton II	*		A A2
B-55489	840±90	1160-1270 (.790)	Tiwanaku V – E. Pacajes	Lukurmata/Misiton II	*		A A2
SMU-2121	1473±377	210-900 (.920)	LF 1 - Tiwanaku V	Lukurmata/K’atupata	*		A A2
B-91780	1790±60	140-260 (.747) or 280-320 (.253)	LF1 – 2	CK-65 (Kirawi)	*		A
B-91777	1630±60	380-480 (.643) or 480-530 (.304)	LF1 – 2	CK-65 (Kirawi)	*		A
B-91776	1490±60	530-640	E Tiwanaku IV	CK-65 (Kirawi)	*		A A2
					*		
B-91778	940±40	1030-1070 (.385) or 1080-1130 (.411) or 1140-1150 (.204)	E Tiwanaku V – E Pacajes	CK-65 (Kirawi)	*		A A2
OS-2441	1040±35	990-1020	use or construction of	suka kollu	*		A, A3
OS-2540	820±30	1210-1260	use or construction of	suka kollu	*		A, A3
OS-2538	1070±30	960-1000 (.728) or 900-920 (.272)	use or construction of	suka kollu	*		A, A3
OS-2539	1070±30	960-1000 (.728) or 900-920 (.272)	use or construction of	suka kollu	*		A, A3
OS-2654	1030±35	990-1020	use or construction of	suka kollu	*		A, A3
OS-2651	930±30	1040-1070 (.338) or 1080-1130 (.453) or 1140-1150 (.209)	use or construction of	suka kollu	*		A, A3
OS-2564	1360±40	640-690	use or construction of	suka kollu	*		A, A3
OS-2649	1290±50	680-770	use or construction of	suka kollu	*		A, A3
OS-2557	950±30	1030-1060 (.35) or 1090-1120 (.396) or 1140-1150 (.254)	use or construction of	suka kollu	*		A, A3
OS-2565	690±30	1280-1300 (.751) or 1370-1380 (.249)	use or construction of	suka kollu	*		A, A3
OS-2544	980±30	1010-1050 (.562) or 1090-1120 (.269) or 1140-1150 (.169)	use or construction of	suka kollu	*		A, A3
OS-2652	990±30	1000-1040 (.751)	use or construction of	suka kollu	*		A, A3
OS-2559	1220±40	780-880 (.923)	use or construction of	suka kollu	*		A, A3
OS-2653	1440±45	590-660	use or construction of	suka kollu	*		A, A3

* Not described or not mentioned in references.
** See Ziółkowski et al. (1994)
*** Personal communication Dr. Aleksey Vranich, 2000.
**** Personal communication Dr. JoEllen Burkholder, 2000.
***** Dates with codes from SMU-2285 till B-91778 have phase context “established” according to results of dating and calibration (Janusek 2003) – not according to sample context.
(?) Three dates from Loreto Viejo are hard to define its context.

Table 3. Distribution of ^{14}C dates by relative chronological phases and regions.
Distribución de datos ^{14}C en relación a fases cronológicas y áreas geográficas.

	Titicaca basin & Tiwanaku	Moquegua	Northern Chile	Cochabamba	
Not described / other	51	8	11		70
V / Decadent Derived	25	3		1	29
IV / Classic	8	1		2	11
III / Early	5				5
II	4				4
I	12				12
Total	105	12	11	3	131

mine pit at the end of XIX century. Fragments of textile and bone were submitted to La Jolla laboratory in 1979. These dates were calibrated alone, in another set.

In the second approach, the main purpose was to add absolute date evidence to discuss Ponce Sangines' five epochs scheme. Calendar year determinations obtained after cumulative calibration of the subsets of dates related to phases would have helped in reviewing relationships between relative chronological periods. Unfortunately, from the whole set of Tiwanaku radiocarbon dates, less than half had well-described cultural contexts (Table 3). The subsets of dates related to five phases were formed by ^{14}C determinations from sites in the Titicaca region, as it is the only region where all phase existed. In fact, all phases were represented only in Tiwanaku itself, according to Ponce Sangines. Tiwanaku I phase was represented by six dates, four were originally connected to Tiwanaku II, four to Tiwanaku III, six dates with Tiwanaku IV (two of "Late Tiwanaku IV" (Kolata and Ortloff 2001) context from an undescribed location in the Tiwanaku site, one from Kalasasaya and three from Kantatayita). Twenty-seven dates were associated with Tiwanaku V context: thirteen came from described locations in Tiwanaku (Kolata and Ortloff 1996), and the others were assumed to be Tiwanaku V, because of their non-Tiwanaku precedence (four dates are from Isla del Sol, two from Iwawe, and eight from Lukurmata).

Main Areas of Tiwanaku Cultural Influence

The calibration results of sets chosen by geographic criterion are presented in graphic form in Figure 1 and in Table 4. The picture below shows results for all subsets. For better presentation it was divided into two parts of the same scale. The X axis stands for calendar years BC / AD after calibration. The Y axis stands for a scale of the density of probability for joint calibration sets. Each line represents different "geographical" set of dates. Differences between maxima in graphs result from the fact that probability distributions after calibration have kept a characteristic of normal probability distribution - the area underneath the line is equal to 1.

The results for all dates from the most important region of Tiwanaku culture –the Titicaca basin– are presented by the solid line (Figure 1, upper part). As this figure presents a graphic depiction of the probability distribution after calibration for all dates from the Titicaca basin, not surprisingly, it covers the entire time axis considered for the Tiwanaku culture period. The results show the consistency of the data set: with 68% (1 sigma) of area encompassing the main calibrated age between A.D. 520 and 1060, or approximately 500 years (Table 4). It should be stressed, that the line covers all time intervals suggested in literature for the time of the Tiwanaku state existence. When the group of dates related to Tiwanaku Waru Waru construction and use is excluded, the calibration gives a wider range for the 1 sigma area of probability distribution: A.D. 380-1030. When treated more subtly (Figure 2, upper section), dates from the Titicaca basin also show some interesting tendencies. Calibrated alone, the fourteen dates from Waru Waru, at 1 sigma, have a small range (Table 4). The main range, A.D. 950-1070 (.500), shows little coincidence with the main range of highest probability for the set containing 54 of the Tiwanaku

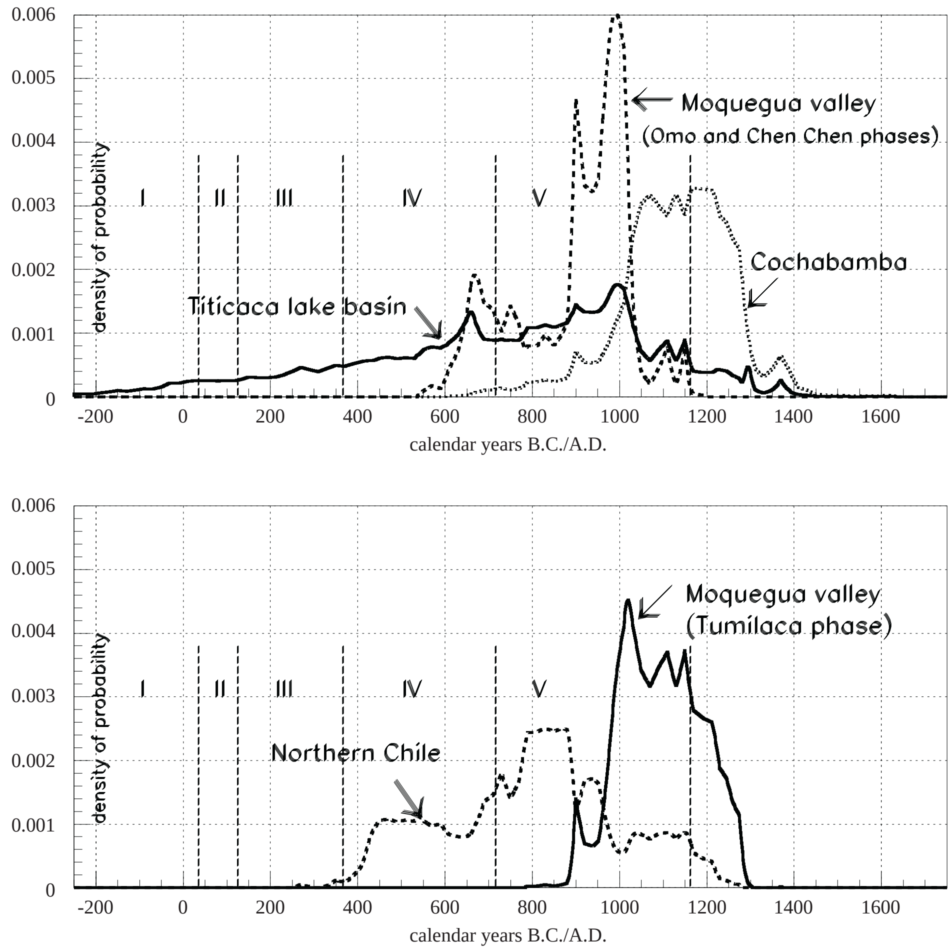

Figure 1. Results of Tiwanaku cumulative calibration of ^{14}C dates, all regions combined.
Resultados calibraciones de ^{14}C de las regiones presentadas.

period dates (590-1020 (.972) at the 1 sigma level) and no coincidence at all with the set of twelve Late Formative dates (10 B.C. - A.D. 560 (.992) at 1 sigma, and 839 B.C. - A.D. 723 at 2 sigma level. However, more data is necessary because such important areas as Juli Pomata, Huatta or Umasuyu (according to J.W. Janusek's communication with Charles Stanish mentioned in Janusek 2003) are still not represented in this Tiwanaku radiocarbon database.

The most important area of Tiwanaku influence found outside the Titicaca basin so far is represented by the remains of a Tiwanaku administrative center in Moquegua valley (Kolata 1993a). During the second phase of Tiwanaku occupation (Chen Chen phase) the Moquegua valley was probably controlled from Chen Chen (Kolata 1993a). I do not understand this sentence, as it is it does not make much sense. The subset contains only four dates and results are generally in accordance with the interpretations of Tiwanaku state activity in Moquegua. The time interval between A.D. 600 and 700 (630-720 (.789) or A.D. 740-770 (.211) at 68% probability level) is related to a single date that represents the Omo phase. About 100 years later the second period of occupation of the valley, the Chen Chen phase, begins. This interval lasts from ca. A.D. 900 till 1050 (890-920 (.255) or 930-1010 (.745) at a 68% probability level) and marks the supposed main period of Tiwanaku expansion into the Moquegua valley (Kolata 1993a).

Date ranges for two Tiwanaku phases are separated by a few decades (Figure 1, upper part; Figure 2, lower part). However, despite the limited

Table 4. Calibration results - highest probability intervals for the subsets of dates from different regions of Tiwanaku cultural influence.
Resultados de calibraciones de intervalos altamente probables por subseries de datos de diferentes regiones bajo la influencia de Tiwanaku.

Region	Calibration subset		Probability interval of calendar age (AD) after calibration 1 sigma	2 sigma
Titicaca basin	Subset A 98 dates		520-1060 (.865)	BC 60-1310 AD (.994)
	84 dates (without Waru Waru)		376-1034 (.980)	BC 120-1280 AD
	Late	17 dates	21-539	BC 790-660 AD
	Formative 1 2	18 dates	6 BC - 560 (.992)	839 BC - 723 (.957)
	Tiwanaku 4 5	(54 dates)	592-1021 (.972)	317-1308 (.987)
	Waru Waru		950-1070 (.500) or 1070-1160 (.215) or 630-690 (.115)	930-1170 (.544) or 630-690 (.115) or 1180-1300 (.118)
Moquegua Valley	Omo	(1 data)	630 - 720 (.789) or 740 - 770 (.211)	560-820 (.981)
	Chen Chen	(3 dates)	890 - 920 (.255) or 930 - 1010 (.745)	780-1040 (.973)
	Tumilaca	(8 dates)	970 - 1210	850-1260 (.964)
Northern Chile valleys	(6 dates from funeral context)		430 - 550 (.189) or 660 - 970 (.811)	410-1160 (.994)
Cochabamba	(3 dates from funeral context)		1030 - 1250	860-1330 (.969)

quantity of dates, this might eventually support the theory of an ephemeral character of Tiwanaku presence during the Omo phase and abandonment of the valley at the end of that phase, before the new and limited colonization by Chen Chen phase settlers (Owen 1994). Again, more data will be necessary to better evaluate the evidence, especially in light of new discoveries at La Cantera, that may suggest coexistence of two Tiwanaku communities, Omo and Chen Chen in the valley (Owen 1999:1).

The obtained time ranges for Tiwanaku state in Moquegua valley were compared to time range of post-Tiwanaku cultural manifestations. According to Owen (1992), during the Tumilaca phase former Tiwanaku colonists abandoned the Altiplano state colonies at the middle part of the valley and moved to its upper and coastal areas. The eight samples of this phase came from sites in the coastal area of the valley and from a Chen Chen cemetery. Calibration results presented graphically in Figure 1 point to the time interval of A.D. 970-1210 (at 68% probability level). It is worth mentioning the cumulative calibration of post-Tiwanaku Tumilaca phase and Chen Chen phase dates partially overlap. Two distinct periods in political and cultural history of the region, probably overlapped for almost half a century. If supported by more data, this may be cautiously interpreted as a suggestion for the gradual fall of the Tiwanaku State organization and administration in Moquegua valley. Colonists would have begun to abandon the middle valley and settle in other parts of the region even before A.D. 1000, at the culmination of Tiwanaku state activity, which relates to the Chen Chen phase. The intensive colonization in Chen Chen phase, reminds D.L. Browman's interpretations (1981) of the dramatic efforts taken to stop political and economic recession in the core area of the state.

Calibration results of the dates from sites in Northern Chilean valleys (Azapa and San Pedro de Atacama) gave the greatest probability density interval between ca. A.D. 650 and 950 (at 68% probability level) (Table 4). Later and earlier periods of high probability density, between ca. A.D. 400 and 600 (430-550 (.189) at 68% probability level), and after A.D. 1000-1200 are also possible, but less probable. Because the samples were taken from burial, not settlement contexts it should be remembered that these results can be interpreted

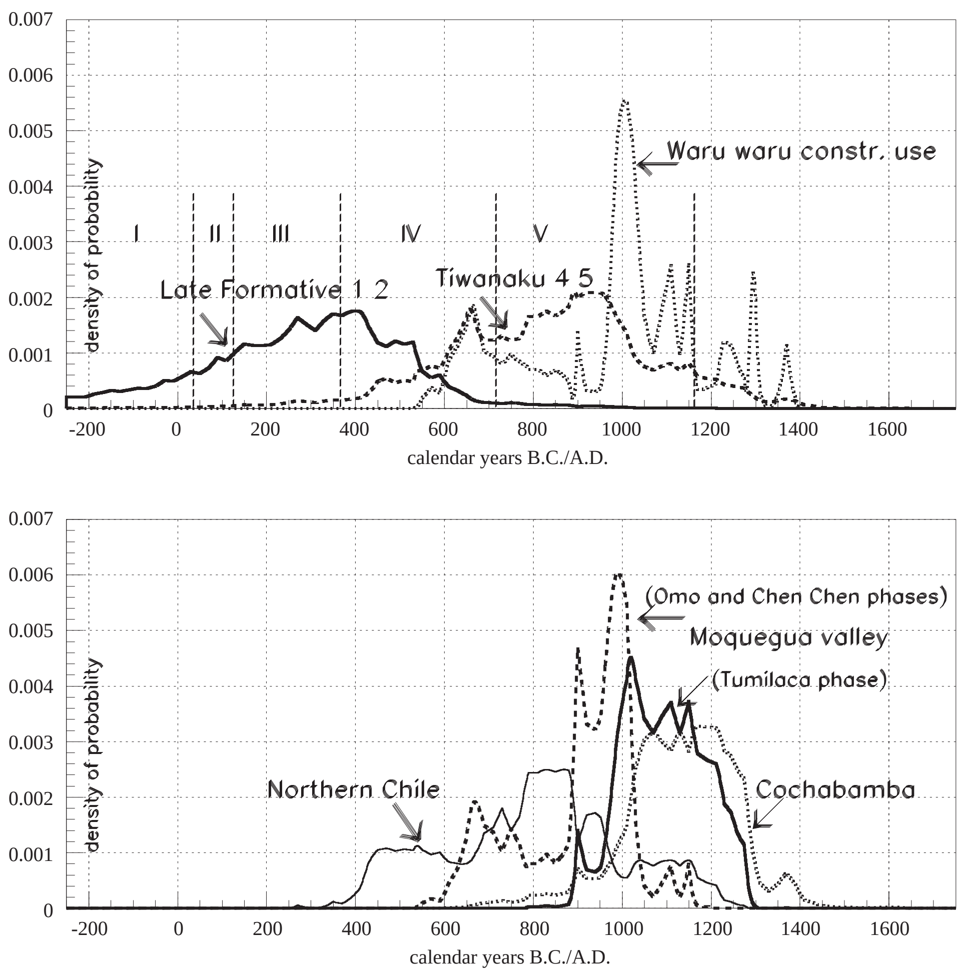

Figure 2. Results of cumulative calibration of ^{14}C dates from all regions. Titicaca basin dates were divided into three subsets. *Resultados de calibraciones de ^{14}C de todas las regiones. Los datos de la cuenca del Titicaca fueron divididos en tres subseries.*

only in terms of vague Tiwanaku influence. It should be stressed that most Chilean dates are significantly later than the only ^{14}C determination from the San Pedro de Atacama oasis, Quitor-6 site (after calibration: A.D. 210-530 (.953). According to researchers (Kolata 1993:275-280; Stanish 1993:83), these areas experienced a different type of Tiwanaku influence, with the oasis thought to be a trading outpost or factory with a small Tiwanaku elite community, while the other valley colonies, in contrast, were established rather for agricultural production or mineral collecting. The calibration of date from Quitor-6 falls within the San Pedro II period (ca. A.D. 300-900), according to Llagostera and Costa (1984).

The last calibrated set of dates came from Cochabamba. The results gave an unexpected range of Tiwanaku activity in the region. The interval of the highest probability density lies between ca. A.D. 1000 and 1250 (Table 4) (at 68% of probability level). These results suggest a very late date of contact, but we need more dates to support this conclusion. These results also contradict the hypothesis that Cochabamba represented a Tiwanaku agricultural province (i.e. Byrne Caballero 1984; Kolata 1993a). Moreover, no evidence of regional centers have been found such as those in the Titicaca basin and Moquegua valley (Kolata 1993:270) and, according to Higueras (1996), there is no evidence for a change in settlement pattern during the Middle Horizon either. Cochabamba results would also contradict Browman's (1981) vision of contacts between Tiwanaku and Cochabamba valleys, with Cochabamba being eliminated from Tiwanaku political and economic domination long before the Tiwanaku decline. Perhaps a possibility of late Tiwanaku or post Tiwanaku peoples migration might be taken into account instead.

Time Relationships Between Relative Chronological Phases

The calibration of sets for epochs I-III (Figure 3, Table 5) gave comparable intervals of probability distribution for each subset. There is also very early evidence that goes back to ca 800 B.C. and even 2000 B.C. in the case of the Tiwanaku I subset. However, some dates may be from questionable and doubtful cultural contexts, though they were described as Tiwanaku I epoch. The upper boundary for the three first phases of Ponce Sangines' scheme is A.D. 500-550 (see also results for Late Formative 1-2 subset, Figure 2, Table 4). Peaks for sets of Tiwanaku IV and V dates overlap partially, but the highest probability density value for each set is distinct. Figure three presents the results of joint calibration of the sets of dates from distinct relative phases and contexts.

Conclusions

I. The first important observation that results from these analyses concerns the Ponce Sangines' chronology. The joint calibration of the described subsets of dates supports the thesis of coincidence of epochs I, II and III in terms of stylistic criteria. Thus there is insuffi-

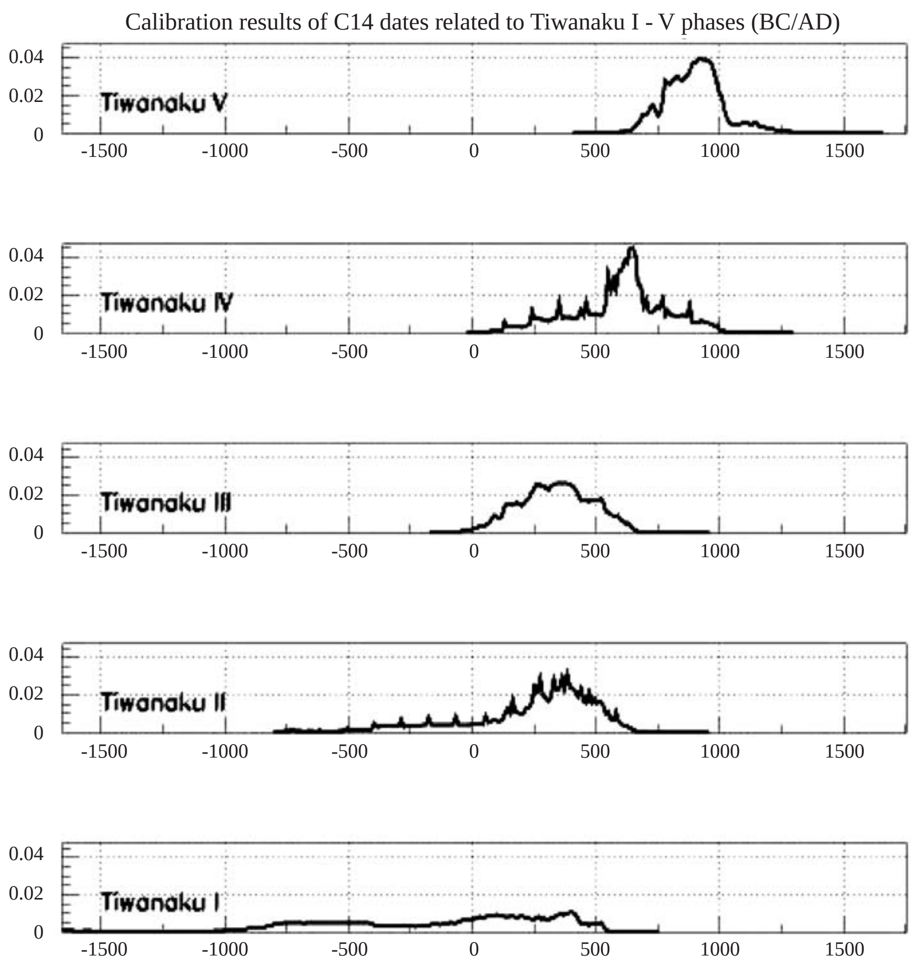

Figure 3. Results of calibration of ^{14}C date sets compared to Carlos Ponce Sangines' cultural phases.
Resultados de calibraciones de datos de ^{14}C comparados con las fases culturales de Carlos Ponce Sangines.

Table 5. Calibration results - highest probability intervals for the subsets of dates compared to Carlos Ponce Sangines' cultural phases.
Resultados de calibraciones con las más altas probabilidades de intervalos para el subgrupo de datos comparado con las fases culturales de Carlos Ponce Sangines.

Calibration subset	Probability interval of calendar age (A.D.) after calibration	
	1 sigma	2 sigma
1- Tiwanaku I (6 dates)	B.C. 800 - 400 (.298) or B.C. 120 - A.D. 470 (.657)	B.C. 940 - A.D. 540 (.846)
2- Tiwanaku II (4 dates)	130 - A.D. 540 (.896)	B.C. 370 - A.D. 630
3- Tiwanaku Early (4 dates)	220 - A.D. 470 (.860)	70 - 620
4- Tiwanaku IV (6 dates) or (5 dates without P-533)*	340 - A.D. 880 (510 - A.D. 780)* (220 - A.D. 970)	210 - 980 (.840)
5- Tiwanaku V (27 dates)	770 - A.D. 1010	600-1060 (.966)

cient support for the hypothesis of a distinct epoch II (Mathews 1995). Phases IV and V are also dubious in nature, though they have been represented by rather stylistically different materials, however, the cumulative calibration results did not support such temporal distinction.

II. Regarding geographic approaches, the time interval of Tiwanaku culture dissemination can be divided into the following main periods: (1) the period before dissemination, which lasts from the beginning of the first millennium until ca. A.D. 400, which is supported by absolute dating evidence from the Titicaca basin, or what is called the 'matrix' of Tiwanaku; (2) the period of spread of Tiwanaku influence outside the Titicaca basin in the second half of first millennium (ca. A.D. 400 - 1200) over the areas of: (a) Moquegua during the Omo phase and Northern Chile (probably to San Pedro de Atacama) between A.D. 400 and ca. 750, and, (b) again later including Moquegua during the Chen Chen phase, Northern Chile, and Cochabamba.

Thus, the most important periods of Tiwanaku cultural dissemination may be divided into overlapping phases that related to the region at which the main Tiwanaku activities concentrate. Between ca. A.D. 600 and 900, the valleys of Northern Chile, and Moquegua (at least according to one date related to the Omo phase of prehistory of the valley) were under Tiwanaku influence. Later, during the Chen Chen phase of colonization of the valley, the main area of Tiwanaku interest was Moquegua, where the traces of provincial character have been documented. The last phase, connected with Tiwanaku or post Tiwanaku traces, was represented in Cochabamba, and Moquegua (by the Tumilaca or post- Tiwanaku phase, during and after the fall of the Moqueguan provincial center).

This hypothesis is not well documented, since there is a significant lack of data for Tiwanaku areas of influence. In some cases, new dates exist, for example for sites in the Moquegua valley, San Pedro de Atacama (personal communication Conklin 2000), but they have not yet been published. There are also some interesting possibilities for direct dating of organic artifacts, i.e. wooden snuff tablets (*tabletas de rape*), or textiles using AMS techniques which require little material.

Dating and cumulatively calibrating sets of dates from different provinces of the Tiwanaku area of influence would sharped our view of the processes of the territorial development and changes in strategy of the Tiwanaku state. Combining archaeological evidence and direct dating in this way is effective only when more radiocarbon dates, of well described samples from known cultural contexts are produced and published.

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Notes

1 This article bases on my Master's thesis written under supervision of Professor Mariusz S. Ziółkowski at the Institute of Archaeology of Warsaw University and paper presented at 50 ICA, Warsaw, 12th July 2000.

2 Computer programs used for the calibration were the Gliwice Calibration Program GdCalib (Pazdur and Michczyński 1989) and the Calib 4.3 of University of Washington Quaternary Isotop Lab. Both programs used calibration curve from 1998 (Stuiver et al. 1998 Radiocarbon 40:1041-1083). I used GdCalib software DOS system version for huge sets of dates to provide data for pictures realised in PAW (Physics Analysis Workstation package) and Calib 4.3 to obtain calibrated ranges from probability distribution (calibration method B) presented in tables.