Renata Holod [updated III/2023]

ONGOING RESEARCH PROJECTS:

I. Archeological and archival survey of the Island of Jerba, Tunisia

A collaborative project with Elizabeth Fentress, American Academy in Rome, and Ali Drine, Institut National du Patrimoine, Tunis.

- 1. Island through Time: Jerba Studies, Volume 1, 2009;
- **2.** *Island through Time: Jerba Studies*, Volume 2 in final preparation to be published with ARCHAEOPRESS
- 3. Website: http://www.sas.upenn.edu/jerba/
- 4. Articles Published:
- **a.** Renata Holod and Tarek Kahlauoi, "Guarding a Well-Ordered Space on a Mediterranean Island" in A. A. Eger, ed. *The Archaeology of Medieval Islamic Frontiers from the Mediterranean to the Caspian Sea* [Boulder, CO: University of Colorado Press, 2019] 47-79;
- **b.** Renata Holod and Tarek Kahlauoi, "Guarding a Well-Ordered Space on a Mediterranean Island" in A. A. Eger, ed. *The Archaeology of Medieval Islamic Frontiers from the Mediterranean to the Caspian Sea* [Boulder, CO: University of Colorado Press, 2019] 47-79;
- **c.** Renata Holod and Tarek Kahlauoi "Jerba in the H 3rd/9th century CE: Under Aghlabi Control?" in *The Aghlabids & their Neighbors: Art & Material Culture in Ninth-Century North Africa*, Glaire D. Anderson, Corisande Fenwick, and Mariam Rosser-Owen, eds. [Leiden: Brill, Hd O series, December, 2017], 451- 469;
- **d.** Renata Holod and Enrico Cirelli, "Islamic Pottery from Jerba (7th-10th century) Aspects of Continuity?" in Patrice Cressier and Elizabeth Fentress, eds. *La Céramique Maghrébine du Moyen Age (VIIIe Xe Siècles)* (Rome: École Française de Rome, 2011) 165-186;
- e. "The Sectarian World of Jerba and the Game of Spolia" in *Against Gravity: Building Practices in the Pre- Industrial World.* Center for Ancient Studies Annual Symposium, University of Pennsylvania, March 2015; http://www.sas.upenn.edu/ancient/publications.html.
- 5. Podcast: http://www.ottomanhistorypodcast.com/2018/03/jerba.html

II. Chungul Kurgan: The Study of a Medieval (Qipchaq) Kurgan

co-author with:

Oleksandr Halenko, Institute of History, Kyiv, Ukraine, Yuri Rassamakin, Institute of Archaeology, Kyiv, Ukraine; and Warren T. Woodfin, Queens College, NYC, NY, USA.

A. Articles Published:

- 1. Halenko, Oleksandr, Rassamakin, Yuri, Woodfin, Warren T., Holod, Renata, "A Cuman Chief's Trophy from Chunhul Barrow: Reuse, Ritual Functions, and Symbolism", Part II *Arkheolohiia 4* (2016), 42-71;
- **2.** Halenko, O., Rassamakin, Yu., Woodfin, W. T., Holod, R. "A Cuman Chief's Trophy from Chunhul Barrow: Reuse, Ritual Functions, and Symbolism, Part I" *Arkheolohiia* 3 (2016), 28 47;
- **3.** Renata Holod and Olexandr Halenko "The Severe Landscapes of 'Mother Sarmatia': Steppe Ukraine in the Eyes of a Polish Gentleman in 1569", *Harvard Ukrainian Studies* 32, *Festschrift for George G. Grabowicz* (2015) 349-376;
- **4.** Grave Goods from the Chungul Kurgan in the northern Black Sea steppe of the thirteenth century", in special volume titled *Mechanisms of Cross-Cultural Encounter of Byzantium and Its Neighbors*, Alicia Walker and Heather Grossman, eds. *Medieval Encounters* **18** (2012) 339-381;
- **5.** W.T. Woodfin, Y. Rassamakin and R. Holod, "Foreign Vesture and Nomadic Identity on the Black Sea Littoral in the Early Thirteenth Century: Costume from the Chungul Kurgan" *Ars Orientalis*, 38/2010, 155-186;

B. Monograph:

The Last Kurgan: A Thirteenth Century Prince's Burial in the Black Sea Steppe, co-author with Oleksandr Halenko, Yuri Rassamakin and Warren Woodfin (in final preparation; proposal submitted to Penn State Press)

1. Outline:

a. Rationale and Scope

The proposed volume represents the culmination of a collaborative research project first undertaken in 2006-2014 to reexamine the artifacts and the material evidence from a thirteenth-century kurgan burial in the southern Ukrainian steppe. These finds represent the single most important collection of goods associated with the Qipčaq people (also known as Cuman-s or Polovtsian-s), a nomadic confederation that dominated the steppe zone from the Danube River to the Caspian Sea in the late 11th through early 13th centuries, and whose diaspora included the Mamluk dynasties of Egypt, and of the Delhi Sultanate.

These finds, furthermore, document the extensive contacts of the Qipčaqs with political, military, and trading networks far beyond the confines of the Black Sea steppe.

In order to integrate the story of these objects with what they reveal about the Qipčaq confederation — which has left no written texts of its own — the first part of the study presents the political and religious life of the Qipčaqs, their history, and their destruction through the lens of the archaeological evidence of the Chungul Kurgan. In particular, the importation, reuse, and adaptation of symbols of power from neighboring, sedentary cultures have shed an unprecedented light on the Qipčaq cultural identity as construed by the survivors who oversaw the burial of the deceased "prince."

The second part will consist of a catalogue of the finds, giving precise information about each object and its probable origin. Two appendices will summarize the procedure of excavation of the kurgan, and the reconstruction of the manpower needed for its construction—both essential foundations for the interpretation of the burial that the authors present in the body of the study.

b. Introduction (8,000 words)

- I. A. Salvage Excavation
 - B. First Description of Finds and Their Immediate Reception
 - **C.** The Post-Excavation History of the Finds
 - **D.** The Genesis of Getty Collaborative Research Project:

This collaborative project came about when Yuriy Rassamakin arrived at University of Pennsylvania as a Fulbright fellow, and appeared at the office of Renata Holod with the story and images of these finds and of their excavation, as well as of the Black Sea steppe in general.

- II. A. Problem of Dating of Finds and Politicized Chronology
 - 1. Typologies employed indiscriminately
 - **2.** Problematic "Qıpčaq" attribution of various Juchid material by Z. Dode and others--although ethno-linguistically identified "Qıpčaqs" may well have been involved in the production of these works of art, in no way does this signify a continued political independence of a Qıpčaq polity separate from the Mongol imperial system
 - **B.** Methodology of dating: triangulation between the artifacts' dates which consistently cluster c. 1200 and the indications of steppe history combined with the energetics to arrive at a date that must be prior to Mongol control of the steppe
- III. A. Importance of Site for Steppe Civilizations
 - B. Importance for Contact Zones between Steppe and Settled
 - **C**. Importance as Historic Inflection Point of Mongol Invasion for Turkic Cultures of Eurasia

Here treatment of the question of model for the assembly of grave goods as **adaptive reuse** as over against the "heirloom effect."

Chapter 1: The Qipčaqs and Nomadic *Habitus* in the Pontic Steppe (24,000 words)

This chapter will present the evidence from the Chungul Kurgan burial and contextualize it via sources—both archaeological and textual—for the religion, culture, and internal organization of the Qipčaqs. Despite the fact that the nomadic Qipčaqs left no written records, the details that emerged in the process of the excavation of the Chungul Kurgan allow for a detailed reconstruction of the burial ritual, including calculations of the likely numbers of persons involved in its construction. Their religious beliefs and practices that left archaeological traces in the excavated mound included the sacrifice of multiple horses and, it seems, one human being, as part of the provisioning of the deceased for the afterlife. Similarly, haunches of mutton and horsemeat, stores of drink, clothing, and armor were included in the burial to equip his continued existence. The burials excavated elsewhere in the steppe zone indicate a kind of normative inventory for nomadic graves of the medieval period, which would include a single horse, along with clothing, armor, and cooking vessels. The inventory of the Chungul Kurgan differs from these by lacking the usual bronze cauldron and by including multiple insignia of power, such as cups, belts, and a straightened gold torque placed in the right hand of the deceased.

- **I.** Statement of Method of Reading the Ritual from the Archaeology of the Kurgan, subsequently contextualized to the extent possible with textual sources and parallels from other archaeological finds
- II. Presentation of the Ritual Phases, with Reference to the Documentation of the Excavation found in Appendix 1
- **A.** Outside ditch—both ritual specialists and other groups (Phase 1)
- **B.** Building of ramparts by selected groups (smaller than previous) (Phase 2)
 - 1. Working access to the burial within the ramparts from the south
- 2. Smaller working party plus ritual specialists working on phases within the space of the ramparts
- **C.** Packing of coffin with its burial goods and temporary location of amphorae in the pit [belts, binding of feet] (Phase 3)
- Explanation for the separation of floors in pit by wooden platforms????
- **D.** Slaughter of horses and sealing of pit (Phase 4)
- **E.** Building of small platform and ritual action there (Phase 5)
 - 1. Close of single sequence of action beginning with digging of surrounding ditch
 - 2. Scarecrow assigned to large platform (?) possibly a year later; associated with the niche oriented east, dog sacrifice, fire
 - 3. When did the human sacrifice take place?

- **F.** Destruction of ritual structures and extinguishing of the fire, with subsequent fill—this marks the end of the involvement of the ritual specialists (Phase 6)
- **G**. Final sealing of kurgan (presumably by a small party of non-ritual workers) (Phase 7)
- **III.** Summary of Findings from Energetics Study:
 - A. Number of Seasons Needed to Complete the Burial
 - **B.** Important point from energetics: phases 6-7 together actually needed more person-days of labor than phases 1-5.
 - **C.** Implications for dating of burial before Mongol conquest
- **IV.** Parallels to Features of Burial Taken from Textual, and other Archaeological and Ethnographic Contexts
 - **A.** Textual Sources, e.g., William of Rubruck, Aubry des Trois Fontaines, etc.
 - 1. Problem of topoi and echoes of Herodotus, etc., in later sources
 - **2.** Accuracy vs. exaggeration in Aubry, Niketas Choniates, etc.
 - **3.** Non-motivated details most likely to be trustworthy (i.e., those that aren't meant to shock the reader)
 - **B.** Human Sacrifice, Evidence from Other Sources, and its likely Function and Meaning
 - **C.** New Observations on Ritual **not** paralleled in other Sites, e.g., "Secret" information from phases of burial subsequent to the erection of the ramparts
- **V.** What the Reconstructed Ritual says about the Status of the Deceased and the Organization of the Group executing the Burial and its accompanying Rituals
 - A. Continuity of inventory with élite burials in Steppe from the Scythians onward
 - B. Energetics as evidence for size of cohort
 - **C.** Turkic and comparative theory of ritual practice
- VI. Sacred Landscape and Selection of the Location of the Burial
 - A. The Molochna River Valley as an ideal place of refuge, with water and game
 - **B.** Continuity with Landscape of the Altai through position on ridge
 - **C.** Continuity with pre-Turkic traditions of the Pontic steppe
 - **D**. Importance of re-used (?) gryvnia similar to Cimmerian (?) material from Besenyszög-Fokorupuszta in National Archaeological Museum, Budapest [apart

from the rings and the chain binding the feet (possibly also of ancient manufacture), the **only** solid gold object—and from a completely different economic-metallic world than that of the late 12th/early 13th century]

Chapter 2: The Black Sea Arena, c. 1050-1240 CE (18,000 words)

The Chungul Kurgan burial attests not only to the internal beliefs and hierarchy of the Qipčaq nomads, but to the extensive networks of exchange represented by its grave goods. These objects, which largely belong to the category of the "extraordinary" rather than "ordinary" inventory of Qipčaq burials, document the connections—either as allies, trading partners, or as enemies—between the Qipčaqs and their sedentary neighbors in the region. The ceramic vessels, the silver cups, and, above all, the textiles, reveal links to Syria, Byzantium, and Western Europe as well as to their more immediate Rus' neighbors. The weapons and armor, in particular, relate to the Qipčaqs' engagement in mercenary service for various neighbors, including Khwarazm, Georgia, Rus', and Byzantium.

I. Explanation of the Framing of the Chapter

- A. History and Geography of the Qipčags in the Regions around the Black Sea.
- **B.** Overview of first century or so of Qıpčaq history in the region from Byzantine-controlled Thrace to Seljuk-dominated Anatolia, in the period from their appearance in the Pontic Steppe to the flight of the Qıpčaq elite into Hungary in the face of their defeat by the Mongols.
- **C.** Modes of Qipčaq interaction with sedentary populations: Diplomacy, oathtaking, trading, and raiding—reflected in material evidence from the Chungul burial

II. Extraordinary Inventory of the Burial

- **A.** Problematic of Agency in the Selection of the Burial Inventory: deceased vs. his cohort
- **B.** Argument against Otroshchenko's "autobiographical" narrative of the artifacts as mementos collected by the deceased
- **C.** Evidence for family/clan/group as agents of the selection of burial goods and the construction of the ruler's "identity" in the burial
- **D**. Problematic of conversion of élites, possible "resistance" of larger group:
 - 1. Devin DeWeese on conversion
 - 2. Known conversions of Qıpčaqs in Kyivan Rus' [See examples enumerated in V. Spinei, "The Cuman Bishopric" in F. Curta *The Other Europe* (Leiden 2008), p. 442, esp. 1223 conversion of Baty mentioned in *Hypatian Chronicle* in Shakhmatov *PSRL* 1908, col. 741.]

- 3. William of Rubruck's witness to pagan rituals for a dead man "claiming that he had been baptized." [Jackson translation, p. 94]
- III. Qıpčaq Mercenary Involvement as Embodied in Arms and Armor
 - **A.** Best armor comparisons from the Tagancha burial—presumably a "Chërniy Klobuk" *foederatus* of Kyivan Rus'
 - **B.** Arms and Armor (and saddles) point in two directions—Rus', Alan / Steppe
 - **C.** Heavy armor evidence of *kataphract* status? Rather than typical light cavalry? [Cf. Russell Mitchell on Battle of Adrianople, *Journal of Medieval Military History* VI, 95-118]
 - D. Textual Sources for Qıpčaq Mercenary Service
 - **E.** Visual sources for Qıpčaq and related Turkic militias [Freer Plate, Dagestan Reliefs, etc.]
- IV. Qipčaq "oversight" of Trade Routes illustrated through ceramics, textiles
 A. Routes through steppe: "Road from Varangians to the Greeks" (Dnipro),
 Saloniy route (to Crimea), Zalozniy route (to Caucasus?) (probably the one used for the historical campaign of Igor'); Arab travelers, esp. Ibn Battuta (c. 1332).
 - **B**. Textual evidence for suzerainty over Sudak
 - C. Ceramics and the routes from Asia Minor to the Crimea
 - **D.** Silk Textiles and connections to the Mediterranean Sea
 - **E.** First mention of confrontation with Seljuks as part of wider economic battle for Anatolian/Black Sea trade
- **V.** Gifts and Booty as products of Confrontations and Alliances [Diplomatic gifts = "booty by other means"]
 - **A.** Rus': textiles [reused embroidery], knives, helmet [?]: Also locks and keys; the settlement of the Rus' on the edge of the steppe allowed the Qipčaqs a close source of booty, trading, and raiding, as well as stimulating, if fractious, political alliances.¹

¹ V. Otroshchenko, Iu. Rassamakin, "Polovetskii khan ili?" *Znanie–sila* 7 (1986) – already advancing the theory of the identification of the "khan" in the burial as Khan Kotian." -- with a dissenting note on Elkina's interpretation by Sergei Aleksandrovich Vysotskii (1923-1998), who seems to have correctly

B. Byzantines and Crusaders: Cups, belts, rock crystal and silver horse ornaments, textiles and embroideries

Applied in particular to the stirrups by Fëdorov-Davydov and, with disastrous results, to belt-buckles by Ilse Fingerlin. The problems of the method become especially apparent in the latter case, as other means of dating of historically attested belt buckles are discarded by Fingerlin in favor of the "evidence" of the chrono-typology. An egregious example being the belt relic of St. Elizabeth of Hungary, which should be dated prior to her death in 1231. Fingerlin rejects such a dating on the grounds that such buckles do not appear in dateable figural representations until about 1240.2 Likewise, she attributes the buckle of the belt belonging to the Holy Roman Reichsschwert to the fifteenth century on the basis of superficial similarities to Dutch examples, whereas there is no physical evidence that the buckle is not contemporaneous with the textile belt of ca. 1200.3 These examples show that "chronotypology" as a method of dating should be applied with caution, and furthermore that it should yield in the face of more substantive evidence for dating when such is available.

- **C.** Confrontation with Seljuks—textual evidence plus physical evidence from Chersonnesos
- D. Alliance with Georgians against Khwarazmians: Battle of Bolnisi/Midori
- **E.** Confrontation with Mongols— NOTE: There is **a total absence** of material from East or Central Asia!
- **VI.** Argument for dating of burial to between the battle at the Kalka R. (1223) and Mongol conquest of Pontic steppe 1241/2. [Assuming three seasons to complete the kurgan, it had to have been begun by 1238?]
 - **A.** After initial defeat by the Mongol avantgarde at Kalka in 1223, pressure on the Qipčaqs to attend the Kuril Tai.
 - **B.** Batu Khan pursues the westward expansion against the Qıpčaq confederation that confronts him on the Volga (1236-ish) -- this time the East European and Volga Qıpčaq elites are both in attendance at the battle, and the survivors collectively flee after the defeat [citations of Rashid al- Din, Yuan chi]

placed the epigraphy in the context of an ecclesiastical textile donation later captured by the Qipčaqs in a raid on a southern Rus' church.

² Ilse Fingerlin, *Gürtel des hochen und späten Mittelalters* (Munich, 1971), 68.

³ M. Schultze-Dörrlamm, *Das Reichsschwert: ein Herrschaftszichen des Saliers Heinrich IV. Und des Welfen Otto IV.: mit dem Exkurs Der Verschollene Gürtel Kaiser Ottos IV.* (Sigmaringen, 1995), 30-34; Fingerlin, *Gürtel*, 475-476, cat. No. 545.

- 1. Köten (Kotian) flees to Hungary in winter of 1238/9, and is murdered in Pest under Béla IV in 1241, probably at instigation of the Hungarian barons who feared the additional power a Cuman/ Qıpčaq army gave the crown.
- 2. Qıpčaq and As/Alan populations that had migrated to Hungary settled in "Greater and Lesser Cumania" "Nagykunság" and "Kiskunság" on the Hungarian plain
- **C.** Mongol control and reorganization of the steppe hierarchy of military and tax administration: cite study by Peter Golden about the re-settlement of Qıpčaqs in the steppe; and comment on Korobeinikov "A Shattered Mirror"
- **D.** Problem of the "substrate": How is it that the Juchids and their trading partners (e.g., Crimean Armenians) came to speak the Qipčaq language? The vastly larger substrate population was left in the Pontic Steppe, where it gave its language to that portion of the Mongol Empire.

Chapter 3: Imported Insignia and Nomadic Code

The third and final chapter will synthesize the meaning of the imported objects and their reconfiguration in the burial of this Qipčaq "prince." Based on the chronological indications already discussed, and the recorded prosopography of the Qipčaq elites of the period, the authors propose an identification of the deceased as Yurgiy Končakovič, son of Končak and great-grandson of Šarukan, founder of this ruling clan line. These noted leaders of the Qipčaq confederation are known from multiple historical sources.

Finally, considering the material evidence in relation to the testimony of sources from the Qipčaqs' neighbors, we will argue that the Chungul Kurgan burial presents material evidence for the coalescence of group identity around the deceased leader of the Qipčaq polity. Such a polity never came to maturity as a state, thanks to the brutal destruction of its leading clans by the triumphant Mongol Empire.

- I. Methodological discussion of Double-Coding or Code-Switching as a phenomenon, illustrated by imported objects appropriated as numinous objects and/or insignia of rank
- II. Importance of Banqueting Equipment
 - **A**. Evidence of the stone statues, *balbal-s*
 - **B.** Comparison with earlier material such as the Khan Kuvrat burial and its banqueting equipment
 - **C.** Communal drinking connected to ritual drinking of leader

D. Problem:

Why both the herbal mixture in the covered cup and the extra wine (or kumis?) In the amphorae?

- **III.** Textiles reused to adapt sedentary regalia to the appearance of horse-riding costume—rehash conclusions of our 2010 *Ars Orientalis* article
- **A.** Evidence of comprehension of these garments' meaning in Byzantine / Slavic contexts
 - **B.** Importance of adaptation to steppe military costume
- **C**. Evidence of purpose-made grave clothing—speaks to the question of agency behind the grave inventory
- **IV**. Belts as code-switching numinous objects [n. b. Discuss the belt from the caftan at the feet]
- V. A Discussion of the Likely Identity of the Deceased and his Lineage
 - A. Array of Possible Candidates in the Appropriate Period
 - **B.** Refuting the Khan Tigak identification [Otroshchenko]
 - **C.** Why Yurgiy would be **the** most possible attractive candidate:
 - 1. Textual sources speak to his renown
 - a. Nasavi [see R. Holod, "Event and Memory: The Freer Gallery's Siege Scene Plate" *Ars Orientalis*, 42/2012, 194 212, esp. n.38],
 - b. Hypatian Chronicle, and
 - c. Secret History of the Mongols [biography of Subotai]
 - 2. Richest known assemblage of grave goods for a Qıpčaq leader
 - **3.** Possible hint in the use of St. George's image on the *loros* embroideries
 - **D**. Comparison with Tagancha:
 - **1.** Indications of a somewhat similar position of rank to our Chungul prince, but belonging to a different nomadic confederation (Chërniye Klobuki), on the other side of the Dnipro R., and with a different set of allegiances
 - **2**. Caution that, because it was not a controlled excavation, we can only speak of what *was* found at Tagancha, not what was absent.
 - 3. Differences, especially the gold gryvnia at Chungul Kurgan.
- VI. An Additional Reference related to secondary use:

Nicola di Cosmo, "Mongols and Merchants on the Black Sea Frontier in the Thirteenth and Fourteenth Centuries: Convergences and Conflicts" in *Mongols, Turks and Others. Eurasian nomads and the sedentary world*, [Brill, 2005]

Reference to the crystal "jewel", which seems to mean the rock crystal pendant for horses, similar to ours. See publications, quoted by di Cosmo, in order to see the original document.

What the Mongol khan of China, Toghon Temur wanted from the West is spelled out very clearly in the diplomatic correspondence with European powers brokered by the Genoese merchant, Andalo da Savignone: horses and other marvelous things (alia mirabilia). He proposed to acquire in Venice between five and ten horses worth two thousand florins, together with crystal "jewels" (iocalia) also valued highly, between one and two thousand florins. (Petech, "Les marchands italiens," p. 555. H. Franke, "Das 'himmlische Pferd' des Johann von Marignola," Archiv fur Kulturgeschichte, 50 (1968), pp. 33–4)

Conclusion (5,000 words)

The conclusion will summarize the findings of the excavation and the problematic of the dating of the site. It will recapitulate the argument for placing the burial between the events of the Fourth Crusade and the Mongol Invasion of 1223-1236. Finally, this conclusion will engage the larger issue of reconstructing nomadic history on the basis of funerary archaeology and the possibilities for moving beyond narrowly archaeological evidence to include textual sources and comparative ethnography.

- I. Reasons for the selection of this location and its numinous associations
- II. Reiteration of arguments for date and identification of the burial

[Discuss Fyodorov-Davydov's use of *a priori* dating for his typologies; big chronological gap between Pletnëva's specialization in the Khazar period and Fyodorov-Davydov's Golden Horde.]

III. Evidence from kurgan and from texual sources for incipient state formation in Pontic Steppe zone, including issues of titulature

IV.

- **A.** Khan/Kaghan issue of *echt* Turkic leadership
- **B.** When Ibn Bibi in his work, *Tevarih –i Al- i Selcuk* refers to the "Khan of the Qıpčaqs," this is an anachronism attributable to the fact that he is writing in the time of Nogai's rule over the "Qıpčaq Khanate," a khanate derived from Mongol supreme rulership, not from the Qıpčaqs themselves
- **C.** Rus' sources are silent on titles, in as much as they tend to refer to individuals by the name of the clan and, perhaps, of their particular

lineage

Catalogue of Finds (40,000 words)

This section will present a complete, descriptive catalogue of the textiles, armor, and other grave goods found in the Chungul Kurgan. Each entry will include succinct presentation of appropriate comparanda and an argument for the date and attribution of each piece. Illustrations in this section will complement the photographs of the objects presented in sequence in the main body of the text.

In parallel, additional illustrative material that cannot be included in the hard-copy monograph will be located on a website to be hosted by the University of Pennsylvania, and the Institute of Archaeology of Ukraine, Kyiv.

Appendix 1: Procedure of Excavation (5,000 words)

Appendix 2: Energetics Calculations (summary) (2,000 words)

Bibliography

Total word count: 120,000, not counting the bibliography

Black and white illustrations: 87

Color illustrations: 59