TECTONIC ARCHAEOLOGY

Subduction Zone Geology in Japan and its Archaeological Implications

Gina L. Barnes

Access Archaeology

Archaeopress Access Archaeology

Archaeopress Publishing Ltd
Summertown Pavilion
18-24 Middle Way
Summertown
Oxford OX2 7LG
www.archaeopress.com

ISBN 978-1-80327-399-0
ISBN 978-1-80327-400-3 (e-Pdf)

Cover: Geology of Asia 225Ma, by Fama Clamosa - Own work, CC BY-SA 4.0 [https://creativecommons.org/licenses/by-sa/4.0/legalcode] [https://commons.wikimedia.org/w/index.php?curid=85632155], modified by GLB with words and circle; the Japanese landmass did not look like this at that time, but its positioning is approximate.

This book is available direct from Archaeopress or from our website www.archaeopress.com

Dedicated to the memory of
William R. Farrand
27 April 1931 — 22 March 2011

"William R. Farrand, Ph.D., professor of geological sciences, director of the Exhibit Museum, and curator, Museum of Anthropology, College of Literature, Science, and the Arts, will retire from active faculty status on June 30, 2000.

"Professor Farrand received his B.S. and M.S. degrees in 1955 and 1956, respectively, from The Ohio State University and his Ph.D. degree in 1960 from the University of Michigan. From 1960-64, he was on the faculty of Columbia University and in 1964-65 he was a visiting professor at the University of Strasbourg in France. He joined the faculty of the University of Michigan in 1965 as an assistant professor and was promoted to associate professor in 1967 and professor in 1974. He was named curator in the Museum of Anthropology in 1975 and director of the Exhibit Museum of Natural History in 1993.

"Professor Farrand's early work centered on the glacial history of Michigan and the American/Canadian Midwest. He studied landforms and their evolution; the crustal rebound that occurs after the ice sheet load is removed from the earth's surface, and the history of the glacial advances and retreats. He was among the first to apply the techniques of radiocarbon dating to elucidate the timing of some of these events. Much of Professor Farrand's scholarship lay at the interface between geology and archaeology; in fact, his career helped to define the field of geoarchaeology. He was particularly interested in the sedimentology, stratigraphy, and paleoclimatology of archaeological and early man sites around the Mediterranean and has spent extensive periods of time working on sites in Syria, Jordan, Lebanon, Israel, Turkey, Greece, and elsewhere in Africa and the Far East.

"Professor Farrand taught courses at all levels and assisted with directing and teaching in the department's summer field program at Camp Davis, Wyoming. He published more than 120 papers, has served on the editorial boards of 4 journals, and has been president and secretary of the American Quaternary Association. Professor Farrand is a fellow of the American Association for the Advancement of Science and has been honored with the Archaeological Geology Award of the Geological Society of America.

"The Regents now salute this faculty member by naming William R. Farrand professor emeritus of geological sciences and curator emeritus."

University of Michigan
Regents' Proceedings 344

Preface

This volume is a compilation of my work in the fields of Geoarchaeology and Geology developed through my research in Japanese archaeology. The result has been the formulation of an approach that is rooted in Plate Tectonics, as Japan is located in one of the world's many subduction zones (active margins) where an oceanic plate is being subducted below (drawn under) a continent. Japanese archaeologists themselves have developed several sub-disciplines that derive from subduction zone processes: volcanism, earthquakes, and tsunami. These can be bundled into a higher order unit that I term 'Tectonic Archaeology', which has a different focus on the archaeological remains than the sister sub-discipline, 'Disaster Archaeology'. By using Plate Tectonics to frame life and death in the Japanese Islands, one comes to a greater understanding of the deep Earth processes affecting the archipelago and the people who have lived through natural disasters (or not) and continue to deal with their occurrences and useful products. Many of the processes are applicable to other areas of the world, either at plate edges or intraplate locations. Therefore, whether one is specifically interested in Japan or not, this book is a first attempt at approaching archaeology through Plate Tectonics, using Japan as a case study. Neither a texbook nor a reference book, it should be taken as an exploration to see what new insights tectonics can offer archaeology. As stated by Cavazza *et al.* "A good knowledge of the interactions between deep processes (geodynamics) and surface processes (climate, erosion transport and deposition of sediments, as well as biosphere) is *a prerequisite* for risk assessment in such highly populated area [sic] as the Mediterranean shores and their hinterlands" (2004: 28, italics added). Although Japan's geology is complicated, it is nothing like the past and present compilation of the Mediterranean region, but the former can serve as a model on which to build understanding.

Readership

The chapters are bundled into an initial exploratory Chapter 1, three substantive Parts, and extended Appendices and Glossary/Indexes. The Parts are relevant to different readerships. **Geoarchaeologists** may be more interested in Chapter 1 – a survey of how tectonic processes are dealt with in the current geoarchaeological literature – followed by Part II which discusses the Japanese sub-disciplines of Tephroarchaeology, Earthquake Archaeology, and Tsunami Archaeology as well as containing chapters on hazard risk mitigation and jade formation. However, much of the terminology used in these chapters is defined and discussed in Chapter 2, accompanied by an extended Appendix and a detailed Glossary of geological terms. Part I, presents subduction zone geology through Japan as a case study and tracks the formation of the Japanese landmass through time from the Jurassic to present-day problems of volcanic soils in Japan. For both **beginning geologists and archaeologists**, Japan can serve as an introduction to subduction zones and deep Earth geodynamics and can illustrate how expertise in the tectonic archaeology subdisciplines widens understanding of the archaeological record. **Japanologists** may find Part I challenging but interesting vis-à-vis their background work in various parts of Japan. Parts I and II aim to give **Japanese archaeologists** a short course in Plate Tectonic processes and present the work of their colleagues in the tectonic sub-disciplines. **Gemologists** may be particularly interested in Chapter 12, which deals with the formation of the true jades (nephrite and jadeitite) in relation to subduction zone processes. It was questions about jade that first got me interested in geology and led me to Plate Tectonics. **Landscape archaeologists** may appreciate my struggle to understand Nara Basin geology and geoarchaeology (Part III) from the time of my dissertation research to the present, while the historical overview in Chapter 1 may give pause for reflection. Two chapters are devoted to correcting misconceptions about volcanic soils: Chapter 7 reveals that not all volcanic soils are beneficial, while Chapter 15 rectifies views on why Japan has a dearth of human and faunal remains.

Most of the chapters herein have been previously published as journal articles or chapters in edited books; they appear here with original publisher permissions. Much of the original texts have been reproduced in this volume with their original bibliographic citations. Where new information supersedes or expands these citations, additional bibliographical references have been supplied. The chapter texts have thus been rearranged, updated, and edited to appear here as an integrated presentation. Their derivations are discussed below, but please see the original publications for their individual acknowledgments.

Chapter Outline

In Chapter 1, I argue that Tectonic Archaeology, as I define it, is a foundation as well as an umbrella for Geoarchaeology. This chapter was originally published under the title "**Tectonic archaeology as a foundation for geoarchaeology**" in *Land* **2021**, 10, 453, 20pp. [https://doi.org/ 10.3390/land10050453]. It is reproduced here virtually unchanged. Rather than an introduction to the volume, this is an exploration of how 'tectonics' and associated processes have been represented in past geo-archaeological literature. It was discovered that there is a lack of discussion about what 'tectonics' actually means and how the term is applied to archaeology. This realization led to Chapter 2, which lays out the basics of subduction zone processes.

PART I A Geological Introduction to the Japanese Islands

Part I is designed to give a brief introduction to most aspects of Japanese geology. Although it can be used independently of the volume, many of the terms are defined in the volume's Glossary of geological terms – useful for non-geologists reading about Japanese geology for the first time – and the contents of the geological belts in Japan are given in Appendix 6. Many of the other appendices are designed to give more concrete information and context to the geological sequences described in the text.

The chapters in Part I draw firstly on three articles originally published in *Japan Review*, with permission from the International Research Center for Japanese Studies in Kyoto (Nichibunken): "**Origins of the Japanese Islands: the new 'Big Picture'**", *Japan Review* 15: 3-48 (2003); "**The making of the Japan Sea and the Japanese mountains: understanding Japan's volcanism in structural context**", *Japan Review* 20: 3-52 (2008); and "**Origins of Japan—the 'Big Picture' Revisited: A Review of New Plate Tectonics Research**", *Japan Review* 25: 169-184 (2013). These have been chopped up, edited, up-dated, and redistributed; the 2003 article forms the basis of Chapters 2 and 3 and Part I Reflections. The 2008 article forms the basis of Chapters 4 and 5. Much of the revised concepts in the 2013 article have been represented in these three chapters and Part I Reflections.

Essentially, the storyline of Chapter 2 documents Japanese involvement in Plate Tectonics research and applies Plate Tectonics principles to understanding tectonic activities in Japan. Chapter 3 discusses the geotectonic construction of the current Japanese Islands and traces the creation of the Japanese landmass at the edges of the China cratons from ca. 510 million years ago to the Miocene. Chapter 4 is about the physical rifting, together with rifting volcanics, of that landmass from the continental edge 15 million years ago to form the present-day Japanese archipelago, then how the main island of Honshu is being impacted by the collision of the Izu Arc. Chapter 5 looks at the evolution of the landscape to form the mountains, basins, and plains that are inhabited today.

Chapter 6 is a newly compiled chapter with material on igneous activity, partly drawn from ***TephroArchaeology of the North Pacific***, edited by GL Barnes & T SODA [Oxford: Archaeopress (2019) with permission of Editor David Davison, but much new material has been gleaned from the general literature]. This chapter describes the igneous rock composition of the Japanese Islands that complements its basement structure of sedimentary Accretionary Complexes as presented in Chapter

3. And it takes as its jumping off point the collision of the Izu Arc with Honshu from 8 million years ago to examine the different ways the two oceanic plates, Pacific and Philippine, are subducting under northeast and southwest Japan respectively, providing very different volcanic and seismic structures to these areas. The more amazing issue is how the two plates overlap under central Honshu which, together with the Izu Arc collision, give this region an unusual tectonic character. The structures in each region from Hokkaido in the north to Okinawa in the south are examined for effects of plate movement and volcanism and how these may have changed over time. The latter is particularly of interest to archaeologists for the distribution of obsidian resources.

Chapter 7 is reproduced here in entirety from its original location as "**Tephra-derived soils of Japan in comparative context**", pp. 202-233 in *TephroArchaeology in the North Pacific*, ed. by GL Barnes & T SODA [Oxford: Archaeopress (2019) with permission]. It provides a counterexample to the generalized notion that volcanic soils are fertile and always productive for farming. Japanese volcanic soils are classed as andosols which occur there in two forms: one incorporating the amorphous clay called allophane and other colloids or the other not having these. Either way, the soils are not fertile, with nutrients captured in the colloids and made unavailable to plant growth or aluminium toxicity when the colloids are absent. There is tremendous archaeological interest in how the andosols were formed, which reflects on the habits of prehistoric peoples intentionally firing stands of *Miscanthus* reeds to increase hunting productivity.

PART II The Tectonic Archaeologies of Japan

Part II consists of three chapters reviewing the work of Japanese archaeologists on evidence of the occurrence of volcanic eruptions, earthquakes, and tsunami. These are also important to modern-day occupants, so that a chapter has been included on hazard determination and response. The final chapter on the formation processes of the true jades, nephrite and jadeitite, illustrates the close relationship between archaeological materials and Plate Tectonics.

Chapters 8 to 10 are reproduced here fairly faithfully except where reformatted, updated, and expanded where necessary. Some of the statements on general geology that appeared in the originals have been moved to other relevant chapters or appendices.

Chapter 8 is based on material in ***TephroArchaeology of the North Pacific***, edited by GL Barnes & T SODA Oxford: Archaeopress (2019) and my article on "**Vulnerable Japan: the volcanic setting of life in the archipelago**", pp. 21-42 in *Environment and Society in the Japanese Islands*, ed. by Philip Brown & Bruce Batten [Corvallis, OR: Oregon State University Press (2015), with permission of Tom Booth, Director of OSU Press]. It explains why volcanic archaeology in Japan is dominated by tephra and how tephra cover changes the landscape as well as impacts on habitation. Several case studies are drawn from the 'homelands' of tephroarchaeology in Tohoku, Kanto and southern Kyushu in the above publications.

Chapter 9 originally appeared as "**Earthquake archaeology in Japan: an overview**", pp. 81-96 in *Ancient Earthquakes*, ed. by M Sintubin, IS Stewart, TM Niemi & E Altunel. Geological Society of America Special Paper 471 [Boulder, CO: GSA (2010); it appears here with permission from Jeanette Hammann, GSA Director of Publications.] It presents the development of archaeoseismology in Japan in parallel with that in the Mediterranean and demonstrates why and how earthquake evidence and damages are so different in the two areas. Recognizing sediment deformation at archaeological sites is an acquired skill for archaeologists. Moreover, this Chapter introduces the distinction between Active Fault earthquakes and subduction earthquakes – a distinction applicable around the world.

Chapter 10 reproduces my article "**The search for tsunami evidence in the geological and archaeological records, with a focus on Japan**." *Asian Perspectives* 56.2: 132-165 (2017) [with permission of Pamela Wilson of Asian Perspectives and the University of Hawaii Press]. The sub-discipline of Tsunami Archaeology is very new and has mainly been conducted in New Zealand, but the 2011 Tohoku-oki Earthquake and subsequent tsunami has jump-started both archaeological and geological work in identyfying tsunami evidence in the archaeological record.

Chapter 11 draws on my article "**Vulnerable Japan: the volcanic setting of life in the archipelago**" noted above but expands to include hazard risk mitigation for earthquakes and tsunami as well as volcanic eruptions. It also deals with the interrelationships of these three tectonically based hazards in addition to examining typhoons and the fear of landslides in Japan. The overlap of Tectonic Archaeology with Disaster Archaeology is acknowledged and discussed because often tectonic and non-tectonic risks combine together to make hazardous living for populations past and present.

Chapter 12 takes us in a completely different direction but ties the work back directly to Plate Tectonics. It reviews the nature of false jades and nephrite as originally presented in my article "**Understanding Chinese jade in a world context**." *Journal of British Academy* 6: 1-63 (2018) [with reproduction permission by James Rivington, Head of Publications and Editor of the JBA]. But it has been expanded to include the problems with jadeite, using Itoigawa jade from Japan as an exemplar, and Chinese *feicui*, a relatively new entrant to the gemological world.

PART III Nara Basin Studies

Part III reviews the geology of the Nara Basin, where I did most of my state formation research, with up-to-date resources. Two geoarchaeological projects (coring and excavation) in the Nara Basin carried out by myself and colleagues tested my dissertation hypotheses, and the summary of that work is reproduced here. The last chapter goes beyond the Nara Basin to provide an explanation why bones are not regularly recovered in Japanese soils. This brings together various strands of tephroarchaeology, soil science, and climate data, and it corrects a critical misunderstanding about the nature of Japanese soils.

Chapter 13 is an updated version of an appendix to my dissertation, "**Nara Basin Geomorphology**," Appendix I to *Yayoi-Kofun Settlement Archaeology in the Nara Basin, Japan*. PhD dissertation, Department of Anthropology, University of Michigan. Ann Arbor: University Microfilms International (UMI, now ProQuest) (1983). This chapter has been vastly rewritten and updated to include reference to current resources available online for Japanese geology, which provide a much richer and detailed view of Nara Basin geology than accessible in the 1970s. Nevertheless, the original appendix underwrote two projects on landscape transformation in Nara that I summarized in 2005 "**Nara Basin Geoarchaeology**", with NISHIDA Shiro and OKITA Masa'aki, *Geoarchaeology: An International Journal* 20.8: 837-860, [DOI:10.1002/gea.20085, reproduced with permission]. This summary appears only slightly updated as Chapter 14.

Finally, Chapter 15 consists of a reflection on why human and faunal remains are relatively rare in Japan by rebutting a common misconception about the nature of Japanese volcanic soils in Japan. Originally presented as "**Acid Soils and Acid Rocks: Implications for Bone Preservation**," at the 2004 Society for American Archaeology (SAA) conference in Montreal, Canada, it was published as a working paper in the panel proceedings (JAA 2004).

Acknowledgments

The acknowledgments for each published article incorporated herein are not reproduced here, but I thank all my colleagues who were involved in commenting on my work and offered constructive criticism as well as permissions to use their illustrations. For the early chapters in Part I, I wish to personally thank TAIRA Asahiko and ISOZAKI Yukio for their time and effort in discussing my original articles of 2003 and 2008.

In writing this new version, I have had the good fortune of communications with John Firth, a participant in the Ocean Drilling Project (ODP) investigating offshore geology of Japan. He has been a tireless reader of Part I and I have benefitted from his many comments, suggestions, and long reading lists. Other geologists and archaeologists, both in Japan and abroad, have kindly answered my questions and provided me with illustrative material. For this final draft, I am particularly indebted to Geoff Bailey for constructive criticisms and encouragement.

Many of the illustrations in PART I were redrawn by Linda Bosveld of the Durham Archaeological Services. I have updated and/or modified these from their original publications listed above as needed. For the remaining illustrations, I have modified figures found in the literature and offer them here for wider understanding. Colleagues who have donated illustrations are ISOZAKI Yukio, OKAMURA Yukinobu, SANGAWA Akira, MATSUDA Jun-ichirō, IIZUKA Yoshiyuki, Harald Furnes, Inna Safonova, Steve Smith, Denice Cabanban, and staff of Kagawa Prefectural Product Promotion Organization, Itoigawa Jade Workshop, and Kamitsukeno-sato Museum; the illustrations were gratefully received, and I also thank those who gave permission to reproduce their figures. All illustrative material is acknowledged in the Figure & Table Sources found at the end of each chapter.

A Personal Journey

My personal journey into geology is detailed here (optional reading) in the spirit of providing context to my research career in archaeology. It demonstrates to **early career researchers** how serendipity and curiosity can lead to unexpected changes in research directions.

My interest in Geoarchaeology began in the mid-1970s, at a time when that field was not yet fully developed and indeed the term was not yet well-known. Geology, on the other hand, has been my early retirement project, culminating in a BSc in Geosciences (Geology) in 2012 at age 65. In between these times, my major focus has been on state formation in East Asia (Barnes 1988, 1993, 2001, 2007, 2015). This volume is thus a record of a personal journey away from and beyond my original thematic study of state formation in Japan, which itself began with a Freshman Year Abroad at International Christian University in Tokyo when I studied Japanese art and archaeology under J. Edward Kidder and became enamoured with Kofun-period elite material culture (*haniwa* sculptures, crowns, gilt-bronze horse-trappings, jade curved beads, and the like). Having begun my Japanese language studies at ICU, I continued at the University of Colorado, taking a BA in Japanese Language & Literature with a double major in East Asian Civilizations. This equipped me with the background to do research in Japanese archaeology at the graduate level, using the Japanese language, once I caught up with archaeological training in the University of Michigan's MA programme.

Landscape archaeology & excavation

From the beginning of my graduate research in 1972 at the University of Michigan, I had two interests: one in the theory of state formation, and the other in the landscape within which the early state developed in Nara Prefecture, Japan (cf. Apx 2: Fig. A). The latter interest was stimulated by my auditing a course in "Archaeological Geology" in 1977, given by Bill Farrand in UofM's Geology Department. This covered dating methods, Plate Tectonics, rocks & minerals, weathering and soils, site sedimentology, geomorphology, paleoclimates, and Quaternary stratigraphy, laying the groundwork for my later geological interests. I dedicate this work to him and was lucky enough to tell him so before he unexpectedly passed away in 2011.

My dissertation fieldwork in the late 1970s in Nara (Barnes 1983, 1988) entailed landscape reconstruction carried out by aerial photograph analysis under the supervision of Prof. Y. Takehisa at Nara Women's University; then, fieldwork in the mid to late 1980s, while teaching East Asian archaeology at Cambridge University (1981–1995), provided opportunities to test that reconstruction (Barnes 1992, 2005) with a geological coring project (JRG 1985, 1986) and an archaeological excavation (Barnes & Okita 1993). The appendix to my dissertation, updated and rewritten, and review of the two test projects are incorporated into Part III herein.

Jade & Plate Tectonics

While next teaching at Durham University (1996–2006), I became involved in a British Museum conference where I presented on jade (Barnes 1996), stimulating my interest in jade as a material – made into important prestige goods in the pre- and proto-historic societies of China, Korea, and Japan. I began by reading about jade; but having no background in Earth Sciences at the time, I did not understand the mineralogy. I thus resorted to reading books on Japanese geology in English, but these were even more impenetrable for reasons described in Chapter 2.1. Out of frustration, I pestered my colleagues in the Earth Sciences Department at Durham University to allow me to sit in on their classes, and when I exhausted those, I enrolled for courses in geology with the Open University. Japan did not form any part of these courses, but everything I learned was applicable to it.

The first thing that I became aware of was that the main books on Japanese geology available when I first started reading about it were still written within the former paradigm of geosyncline theory (Tomari 2005; see Chapter 2.1). As I learned the details about Plate Tectonics at the OU, I rewrote Japanese geology in the new paradigm for myself, just so that I could understand it. I published these study papers on the formation of the Japanese Islands in *Japan Review* (Barnes 2003, 2008, 2013), and they are incorporated here in PART I. These papers do not even qualify as Archaeological Geology since, as my husband complained, “but, there weren’t even any human beings at that time”. They are pure Geology. However, an understanding of Plate Tectonics – and the geology and Earth Sciences that it encompasses – underwrites the “wide variey of research methods and an eclectic approach to data” that is allegedly employed in Geoarchaeology and Archaeological Geology (Rapp 1982: 45); moreover, it makes the collection of data integrative rather than ‘eclectic’.

In the late noughties, I became involved in the Seismological Society of America, via contacts with Iain Stewart and Manuel Sintubin, and gave a paper at the Santa Fe SSA conference in 2008 on earthquake archaeology in Japan, subsequently published in 2010 (Barnes 2010; Chapter 9 herein). My views on volcanic archaeology were published in 2015 (Barnes 2015; incorporated into Chapter 8), while tsunami archaeology followed in 2017 (Barnes 2017; Chapter 10 herein). The Japanese discipline of ‘volcanic ash archaeology’ has received my most recent attention. In 2016, I convened a panel together with my colleague SODA Tsutomu on tephroarchaeology (his translation of the Japanese term *kazanbai kōkogaku*, ‘volcanic ash archaeology’) at the World Archaeological Congress (WAC8) in Kyoto 2016. The papers from this conference together with other invited additions form our edited book, *TephroArchaeology in the North Pacific* (Barnes & Soda 2019, e-book available for free from the publisher’s website). Material that I wrote for this volume has been integrated here in Chapters 6 and 8. It was only upon returning to the problem of jade in order to give a lecture, in 2017 for the Elsley Zeitlyn Lecture Series on Chinese Archaeology and Culture at the British Academy (Barnes 2018), that I realized Plate Tectonics was not a diversion from the study of jades – my initial stimulus for studying geology. True jades have *everything* to do with Plate Tectonics, and so the last Chapter of PART II (12) presents these findings — a fitting closure to a 20-year journey into geology that began with a question about jade.

Of course, I realized along the way that the most salient works on Japanese geology did not appear in English-language *textbooks* but in Japanese books and journals or in specialist English-language geology journals which were often buried behind paywalls of the big science publishers. Thus, it was imperative for me, in order to continue this line of studies, to have a continuing academic affiliation. Having retired from Durham University in 2006, with my Department of East Asian Studies being closed down by the University in 2007, I was set adrift — but rescued by the late Jon Davidson, whose untimely death in 2016 was a great loss to us all and to the field of volcanology. In 2006, Maurice Tucker and Jon Davidson, both of the Durham Earth Sciences Department, agreed to nominate me as a Fellow of the Geological Society of London (FGS) on the basis of my previous geoarchaeological work, and then in 2012, I became a more legitimate Fellow upon completion of my BSc. Jon also supported my work through his Department, and his colleagues John Gluyas, Colin Macpherson, and Andrew (Andy) Aplin, Yaoling NIU, and Mark Allen, plus the able Department Manager Jill Hoult in the Earth Sciences Department have continued that support so that I can access the Durham University Library holdings remotely. I am eternally grateful for the opportunity to have continued my research under their umbrella.

2022 marks 50 years since I arrived at the University of Michigan to study archaeology and met my future husband, David Hughes, who taught me Japanese historical linguistics. Throughout this past half-century, David has been my constant and generous supporter in my career, often acting as my production editor and always as my proofreader for my many publications. I owe him my life as it has been, which I now dedicate to him for the rest of our years together.

Gina L Barnes BA, BSc, MA, PhD, FGS
Emeritus Professor, Durham University
Project Associate in Earth Sciences, Durham University
Professorial Research Associate, SOAS University of London
Fellow of the Geological Society of London

Further Reading

For those interested in pursuing the original research and updates for this book, I include comments here on the most critical resources. Two printed sources were especially useful in the composition of Part I. The first consists of thematic sections of the journal *The Island Arc* entitled "Geology and Orogeny of the Japanese Islands" (vol. 5.3, September 1996) and "Orogeny of the Japanese Islands" (vol. 6.1, March 1997); these represented the first holistic representation of Plate Tectonics and palaeogeography following the final abandonment of geosyncline theory by Japanese geologists. The *Island Arc* publications, in English, are notable for the colour plate reconstruction sequences of the continental clusterings (Maruyama 1997*b*), which could not be reproduced here but were especially enlightening. The second source was the multi-volume series on *Nihon no Chikei* (Japanese Landforms) published in Japanese by the University of Tokyo Press from 2000; the first volume *Sosetsu* (General Introduction) (Yonekura 2001) is especially useful for reviewing neotectonic processes. The descriptions of individual regions in different volumes of this series are informative interpretations of the lay of the land.

Within the last fifteen years since my initial two publications, in addition to innumerable scientific papers in published print and online journals, two sources have been particularly useful in revision. The most recent is a volume on *The Geology of Japan*, edited by Moreno *et al.* (2016), from the Geological Society of London; it is a specialist publication that informs the more accessible presentation here. The initial chapter in that volume (Taira *et al.* 2016) is an update and expansion of "Tectonic evolution of the Japanese island arc system" (Taira 2001) which I used in my original publication of 2003. The other source was a series of articles, in Japanese with English titles and abstracts, on 'New Paradigms' in Japanese Plate Tectonics published in the journal *Chigaku Zasshi* [Journal of Geography]. A review article in Engish accompanied them (Kasahara *et al.* 2010). Drawing on these *Chigaku Zasshi* publications, I wrote an update for my 2003 article in 2013, both published in *Japan Review* as listed above. Many of those comments therein are integrated here.

The New Paradigms series consists of thirty-five articles published in three parts under the title "Nihon Rettō Keiseishi to Jisedai Paradaimu" [Geotectonic Evolution of the Japanese Islands under New Paradigms of the Next Generation] in three issues of *Chigaku Zasshi*: 119.2 (2010), 119.6 (2010), and 120:1 (2011). All articles but one are in Japanese with English titles and abstracts, and most illustrations have captions in both Japanese and English for further perusal. Free PDFs of these articles are available via the *Chigaku Zasshi* website, or directly from J-Stage (Japan Science and Technology Agency [www.jstage.jst.go.jp]). The English abstract for each article gives a good indication of content, while every issue has its own preface in Japanese, in addition to the one overview in English (Kasahara *et al.* 2010).

References (omitting those detailed above)

Barnes, Gina (**1982**) "Prehistoric landscape reconstruction and spatial analysis of artifact discovery locations." *Kokogaku to Shizen Kagaku* 15: 113-131 (in Japanese with English abstract).

–––– (**1983**) *Yayoi-Kofun settlement archaeology in the Nara Basin, Japan*. Ann Arbor, MI.: University Microfilms (ProQuest). Published as Barnes 1988.

–––– (**1988**) *Protohistoric Yamato: archaeology of the first Japanese state*. Anthropological Papers 78 and Modern Papers in Japanese Studies 17. Ann Arbor: Museum of Anthropology and the Center for Japanese Studies.

–––– (**1993**) *China, Korea and Japan: the rise of civilization in East Asia*. London & New York: Thames & Hudson.

–––– (**1996**) "China: questions in jade." *The Times Higher Education Supplement* 6(Dec): ii-iii.

–––– (**2001**) *State formation in Korea: historical and anthropological perspectives*. Richmond: Curzon.

–––– (**2007**) *State formation in Japan: emergence of a 4th-century ruling elite*. London: Routledge.

–––– (**2015**) *Archaeology of East Asia: the rise of civilization in China, Korea and Japan*. Oxford: Oxbow Books.

BARNES, Gina L & OKITA, Masaaki (eds) (**1993**) *The Miwa Project: survey, coring and excavation at the Miwa site, Nara, Japan*. BAR International Series 582. Oxford: Tempvs Reparatvm.

BARNES, Gina L & Tsutomu SODA (eds) (**2019**) *TephroArchaeology in the North Pacific*. Oxford: Archaeopress.

CAVAZZA, William; François ROURE & Peter A ZIEGLER (**2004**) "The Mediterranean area and the surrounding regions: active processes, remnants of former Tethyan Oceans and related thrust belts", pp. 1-30 in *The TRANSMED Atlas: the Mediterranean region from crust to mantle*, ed. by W CAVAZZA. Berlin: Springer.

ISOZAKI, Yukio; Shigenori MARUYAMA & Kazumasa AOKI *et al.* (**2010**) "Geotectonic subdivision of the Japanese Islands revisited: categorization and definition of elements and boundaries of Pacific-type (Miyashiro-type) orogen." *Chigaku Zasshi* 119.6: 999-1053 (in Japanese with English title and abstract).

JAA (Japanese Archaeological Association) (**2004**) *Recent Palaeolithic studies in Japan: proceedings for tainted evidence and restoration of confidence in the Pleistocene archaeology of the Japanese archipelago.* Tokyo: Japanese Archaeological Association.

JRG [Joint Research Group on the Geomorphological Recognition and Land Utilization of Pre- and Protohistoric Japanese Peoples] (co-author) (**1986**) "Natural environments in the Nara Basin through the pre- and protohistoric ages I: geology and geomorphology." *Kobunkazai Kyoiku Kenkyu Hokoku* 16: 1-30 (in Japanese).

–––– (1987) "Natural environments in the Nara Basin through the pre- and protohistoric ages II: descriptions of core samples and analysis on biogenic materials." *Kobunkazai Kyoiku Kenkyu Hokoku* 16(March): 23-74 (in Japanese).

KASAHARA, Junzo; Osamu SANO & Nobuo GESHI *et al.* (**2010**) "Overview of a Special Issue on 'Geotectonic Evolution of the Japanese Islands under New Paradigms of the Next Generation (Part I-IIII)'." *Chigaku Zasshi* 119.6: 947-958 (in English).

MARUYAMA, Shigenori; Yukio ISOZAKI & Gaku KIMURA *et al.* (**1997**) "Paleogeographic maps of the Japanese Islands: plate tectonic synthesis from 750 Ma to the present." *The Island Arc* 6.1: 121-142 (in English).

MORENO, Teresa; Simon WALLIS & Tomoko KOJIMA *et al.* (eds) (**2016**) *The geology of Japan*. London: Geological Society of London.

RAPP, George Jr & John A GIFFORD (**1982**) "Archaeological geology." *American Scientist* 70.Jan-Feb: 45-53.

TAIRA, Asahiko (2001) "Tectonic evolution of the Japanese island arc system." *Annual Review of Earth and Planetary Sciences* 29: 109-134.

TAIRA, Asahito; Y OHARA & SR WALLIS *et al.* (**2016**) "Geological evolution of Japan: an overview", pp. 1-24 in *The geology of Japan*, ed. by T MORENO *et al*. London: Geological Society of London.

TOMARI, Jiro (**2005**) "The concept of geosynclines and plate tectonics in Japan." *Kagakushi Kenkyū* 44.233: 23-32.

YONEKURA, Nobuyuki; Sohei KAIZUKA & Michio NOGAMI *et al.* (eds) (**2001**) *Regional geomorphology of the Japanese Islands, Vol. 1: Introduction to Japanese geomorphology [Nihon no Chikei]*. University of Tokyo Press.

Style Notes

• Abbreviations and acronyms can be found in Appendix 1.
• Special effort has been made to explain geological terms in the text; they appear in sans serif font on first use in each Chapter and are defined and indexed in the Glossary.
• Japanese administrative units (prefectures and districts) are presented in Apx 1: Fig. A, while Japanese archaeological periods are given in Apx 1: Tables A, B.
• Geological periodization is given in Apx 3.
• East Asian names are usually given surname first; the surname is in SMALL CAPS when accompanied by the personal name.
• British spelling is adopted but using 'z' as in *The Times* newspaper. Punctuation is generally American-style except for abbreviations (British abbreviations do not take a full stop [period] if the abbreviation includes the last letter of the word: e.g., ed. [editor] but eds [editors]).
• Dates are given coming forward for all BP, BC, and AD dates: e.g. 10,000–6000 BP = from 10,000 to 6,000 years ago; dates in the thousands BC are given without commas, as in dates AD. Millions of years *ago* are abbreviated as 'Ma' (*mega annum*); thousands of years *ago* are 'ka' (*kilo annum*); and billions of years *ago* Ga (*giga annum*); mya may also be used for million years *ago*.
• Date ranges (*duration*) are given as 'years', e.g., ky = a thousand years, my = a million years
• Japanese words and placenames are given in modified Hepburn (e.g. Tanba, rather than Tamba; Sanbagawa, rather than Sambagawa), though personal choices of name spellings are maintained if different from Hepburn romanization (e.g., Wadati, rather than Wadachi).
• Macrons for long vowels in Japanese are generally not shown except for italicized terms in the text or in bibliographical references.
• Certain terms are given capital letters for emphasis, as with Plate Tectonics, in that they reflect important concepts that have specific definitions in Japanese geology: e.g., Accretionary Complexes, Active Faults, Active Volcanoes.

Referencing System

• Acronyms are given in Apendix 1.
• Items in the glossary of Geological Terms appear in the text in sans serif font.
• The Glossary of East Asian Words is keyed to italicized terms in the text; kanji and meanings are given together with Chapter occurrence.
• Cross-references to Chapters and Figures in this volume are capitalized (Chapter, Figure, Table); those in other works are lower case (ch., fig., table); 'cf.' is used to mean 'see'.
• Figure and Table titles are by chapter, e.g., Figure 1.1 (first Figure in Chapter 1); their sources are given at the end of each chapter text before the bibliography.
• Figures and Tables in the Appendices are given letter referents, e.g., Apx 2: Figure A., specific to that appendix.
• Bibliographies for each chapter are included after that Chapter or Appendix; there is no overall book bibliography.
• Items in the bibliography that have no date (n.d.) are, if possible, given the date of the latest cited reference therein, e.g. ≥2012 (published in or later than 2012).
• DOI numbers: these can be inserted into the 'find' field at [doi.org] to find the document online.

Table of Contents

BOXES (including illustrations)

FIGURES

APPENDIX FIGURES

TABLES

APPENDIX TABLES