

# Accepted Manuscript

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Editorial

**Hiroshi Machida –respected tephrochronologist, teacher, leader**

**In appreciation**

Professor Emeritus Hiroshi Machida (Hiroshi hereafter) is the leading tephrochronologist of his generation in Japan. Perhaps more than any other geoscientist from Japan, Hiroshi carried the insights and advances of tephra studies and their application in palaeoenvironmental and archaeological applications, landscape processes, and volcanology and hazard analysis, to the outside world through a succession of papers and books written in English and through conference presentations. He has been the ‘international face’ of tephra studies in Japan.

Derived from disciplined and sustained field work and meticulous laboratory analysis, Hiroshi’s work, including seminal discoveries, is widely recognized both internationally and in Japan. For many tephrochronologists all around the world, seeing Hiroshi’s friendly face at conferences, and his engaging and gentle personality, have always engendered assurance, respect, and a sense of well-being within the discipline. Hiroshi has attended specialist international tephra meetings for three decades, always contributing papers containing new ideas and new data to help solve Japanese-based or wider research

problems, and at the same time supporting and encouraging students and colleagues in their work. As well as leading the international tephra group—originally called the Commission on Tephrochronology of the International Union of Quaternary Research (INQUA)—for 8 years as both vice-president and president, Hiroshi also organized and ran several international conferences in Japan, and he has led numerous field trips for a variety of organisations in Japan and other countries including New Zealand.

To many colleagues and students in Japan, Hiroshi has been a supportive mentor and leader who encouraged a stratigraphic approach with emphasis on sound, fundamental field observations. Disciplined and serious in his teaching and administrative work that spanned nearly 40 years, Hiroshi's approach and personal character have won him the deepest respect and affection of several generations of students. He has generously hosted many researchers and visitors to his laboratory from many countries and shared his findings and understanding with them. To all his students, and to his many international friends and colleagues, Hiroshi is, and always will be, *Machida-sensei* ('respected, masterful, and wise teacher'). It is therefore appropriate that we affectionately commemorate his contributions and career in tephrochronology and other disciplines through this collection of papers, many arising from the "Active Tephra" meeting held in Kirishima in Japan, 2010, at which Hiroshi presented an enthralling public lecture to a packed hall (Fig. 1).

## Early life

Hiroshi was born in the centre of Tokyo, Japan, in February, 1933, where he grew up. It was a tough time for him during WWII with many air raids on the city. After WWII, unfortunately Hiroshi came down with an illness and went to a rural area to convalesce. However, this provided an opportunity for Hiroshi to become interested in nature through activities such as mountain climbing and insect collecting during his year-long medical treatment (Fig. 2). Although at one time on course to train as a medical doctor, Hiroshi's convalescence experiences led him to an alternative career as a researcher broadly in natural history.

Following an undergraduate degree in physical geography at the University of Tokyo in 1957, Hiroshi was accepted into a master's programme at the University of Tokyo in 1959. Although most Quaternarists will know Hiroshi from his tephra work, his early studies focussed on the development of recent and rapid erosional events in mountainous areas. This was the main work undertaken during his master's, learning geomorphological and stratigraphical methods. A case study on a huge landslide and the formation of accumulation terraces in historical times in the Japanese Alps resulted in Hiroshi becoming increasingly interested in abrupt and catastrophic geologic events. He was influenced by guidance from his supervisors who emphasized that present geologic processes and events are keys for understanding geomorphic processes of the past. Hiroshi undertook advanced

studies following his masterate in other fields (Machida, 1959, 1962), and shortly after he was appointed as a research and teaching assistant on the staff of the Department of Geography at Tokyo Metropolitan University in 1959 (Fig. 3). He was awarded his Ph.D. in geography at the University of Tokyo in 1962.

### **An interest in tephrochronology**

A project on the geomorphic evolution of Osawa valley of Fuji volcano (Iwatsuka and Machida, 1962), one of his succession of studies on the relationship between a large landslide and subsequent landform changes, was transformational for Hiroshi. At the foot of Mt Fuji, he observed tephra beds derived from Fuji and he mapped their distribution using isopachs to complement geomorphological and geological mapping. Eventually, in Machida (1964), Hiroshi considered not only the chronology of the geomorphic development but also that of volcanic activity, archaeological material, buried soils, and other aspects. This multidisciplinary approach was to become a feature of Hiroshi's long-lasting studies. At that time, perhaps, Hiroshi realized and perceived the significance of tephra studies. This realization thus became one of the most important events in his professional career (Fig. 4).

Following this early work, Hiroshi married and commenced surveying tephra beds in the Oiso hills that at one time formed the eastern foot of Hakone volcano before being cut

off by an active fault recognized now to be a plate boundary. The Oiso hills have a very complicated geologic structure with more than hundred proximal middle to late Pleistocene Hakone- and Fuji-derived tephra beds sandwiched by marine and terrestrial deposits and buried soils (Machida and Moriyama, 1968; Machida et al., 1971).

Hiroshi's seminal papers in the journal *Quaternary Research* (published by the Japan Association for Quaternary Research, JAQUA) (Machida, 1971) and the *Journal of Geography* (published by the Tokyo Geographical Society) (Machida, 1973; Machida et al., 1974) documented the geomorphic development of the coastal plains in south Kanto (the region that includes Tokyo and Yokohama). This work remains the Japanese standard Quaternary chronology describing glacial eustatic sea-level changes and marine terraces. In particular, Machida and Suzuki (1971) discussed the marine terrace formed by the transgression in the last interglacial culmination (MIS 5e) and the stable accumulation rate of tephra beds according to radiometric ages. These results were published internationally in the proceedings, entitled *Quaternary Studies*, of the 1973 INQUA Congress held in New Zealand (Machida, 1975), and have been cited many times. In the 1970s, the chronology of late Pleistocene marine terraces had been established by U-series dating on several coral reef areas such as those on the Huon Peninsula (Papua New Guinea), Ryukyu (Japan), and so on, revealing the relationships between landform development and sea-level change. At that time, tephrochronological studies on this topic were pioneered by Machida (1975).

In order to distinguish individual tephra beds, Hiroshi's collaboration with Prof. Fusao Arai (1925-2004) at Gunma University became firmly established (Fig. 5). Both were strongly influenced by Prof. Kunio Kobayashi at Shinshu University, the first president of the Commission on Tephrochronology (COT) of INQUA (1961-1973), who described the principles and techniques of tephrochronology emphasizing that not only field observations but also petrographic analyses of tephra components were necessary for distinguishing tephra layers. In Japan, petrographic analyses of mineral assemblages, and the measurement of refractive indices (RIs) of volcanic glass shards and loose crystals or phenocrysts, have been employed as standard techniques (Arai, 1972), although the use of RIs as a tool for correlation was not common in other countries (see Lowe, 2011).

The high point of Hiroshi's career must be the discovery of widespread tephra beds in and around Japan. Up until the middle of 1970s, it had been believed that tephra beds were distributed in relatively limited areas extending a few hundred kilometres from source volcanoes. The idea that tephra beds were much more widespread in Japan was proposed by Prof. Yoshio Katsui (1926-) at Hokkaido University. He described the widespread distribution of the Shikotsu 1st Tephra in Hokkaido (Katsui, 1959), and this report was followed by that of Prof. Kunio Kobayashi who showed that the Ontake 1st Tephra had been deposited in Tokyo around 200 km east of the source volcano (Kobayashi et al., 1967). Although initially Prof. Kunio Kobayashi's discovery was quite controversial, Machida and

Arai (1976) correlated a thin and subtle fine vitric ash bed (sometimes it is preserved as a cryptotephra in tephritic soils) around the Tanzawa Mountains with the most well-known, voluminous ignimbrite named Ito pyroclastic flow deposits (the local name is *Shirasu*, meaning white sands) around the Aira Caldera in south Kyushu 900 km southwest of the Tanzawa Mountains. They discussed the linkages between pyroclastic flows and associated distal fall-out of fine tephra, later conceptualized as co-ignimbrite ash-fall deposits by Sparks and Walker (1977). Eventually, it was confirmed that this tephra bed, named Aira-Tn Tephra (AT), covers entirely the islands of Honshu, Shikoku and Kyushu ( $> 4 \times 10^6 \text{ km}^2$ ). This discovery, one of the most significant findings in Japanese tephra studies, shocked all Japanese Quaternarists, and led to the famous statement by Prof. Kazuaki Nakamura (1932-1987), one of the important geoscientists in volcanology and plate tectonics, "I am feeling that I am forced to inhale a narcotic".

Hiroshi's achievements are not confined to field survey and the publication of scientific results in academic journals. He also wrote books. In 1977, Hiroshi was the sole author of "*Kazanbaiwakataru*" which means "What does tephra tell us?" The book was subtitled "The history of volcanoes and plains". It was accessible to scientists in other disciplines, emerging researchers, and students. The book conveyed how Hiroshi's tephra studies had engendered excitement in the process of tracing the widespread AT tephra. The attractive book probably influenced many of today's active tephrochronologists when they

were young. Also, this book resulted in the wide dissemination of the term “tephra”, which is now commonplace in geosciences in Japan (and elsewhere).

From the 1980s to 1990s, Hiroshi developed his studies on many widespread tephra beds over a wide range of time and space. By the end of the 1990s, most middle to late Pleistocene widespread tephra beds from many sources in the Japanese islands had been revealed. Regarding the distribution of the AT tephra, it was shown to extend beyond the Japanese islands to the Korean Peninsula and China (Machida and Arai, 1983, 1988; Machida et al., 1983; Eden et al., 1996). Hiroshi’s work on widespread tephra beds was not limited to the volcanoes in Japan. He also recognized a thin alkali-rich vitric ash bed in north Japan that was derived from a major eruption of Baegdusan (Changbaishan) volcano, located on the border between China and North Korea, in the 10<sup>th</sup> Century (Machida and Arai, 1983; Machida et al., 1988, 1990). Although the field work in northeast China under severe conditions was difficult, Hiroshi and his collaborators, Hiroshi Moriwaki and D.C. Zhao, documented both the distribution of the widespread alkali tephra bed and the likely impacts that such a large-scale eruption would have had on civilization and ecosystems around Baegdusan volcano (Fig. 6). Hiroshi also visited and worked in Papua New Guinea (Fig. 7; Machida et al., 1996).

Hiroshi’s most recent interests have been in reconstructing a realistic image of the environments of the Quaternary. Of course, his approach is based on tephrochronology. For

example, in order to consider the relation between environment and humans, Hiroshi discussed the impact of the large-scale Holocene eruption of the Kikai-Akahoya tephra (7.3 ka: Machida and Arai, 1978) on Jomon culture (the time in Japanese prehistory from about 15,000 to 300 calyears BP, characterized by extensive use of fine potteries) and on the vegetation in south Kyushu Island (Machida, 1984, 2002). Many Quaternarists, including archaeologists, palynologist, and phytolith researchers, have been very interested in this issue, and there is considerable controversy over the discontinuity in the Jomonculture combined with the duration of the impacts of the eruption on the vegetation. Machida (1984, 2002a) proposed that a major cultural discontinuity was caused by this eruption.

Moreover, Hiroshi's interest and contributions to Quaternary research have been wide ranging, not just studies on tephras. He also strongly promoted collaboration with scientists in other disciplines. This interdisciplinary collaboration resulted in the publication of three books: (1) *Quaternary Studies* (2003) edited by Hiroshi Machida and five others; (2) *Quaternary Perspectives: the Earth's Present Status and Near Future*" (2007) edited by Hiroshi Machida, Shuji Iwata, Akira Ono, and published by University of Tokyo Press; and (3) *Digital Book: Progress in Quaternary Research in Japan*" (2009) edited published by JAQUA. He has also written review articles on the volcanic history of Japan (Machida, 2002b, 2010).

**Collaborator, leader, and mentor**

The fundamental contributions made by Hiroshi have stemmed from his early realization that the power of tephra studies comes through collaboration and inter- and multi-disciplinary research. The effectiveness of such collaboration is demonstrated by the inclusion of around 20 co-authors on more than 30 refereed papers and more than 10 books on which Hiroshi was first author. These co-authors specialized in many subjects such as geomorphology, stratigraphy, tectonics, paleontology, seismology, paleoclimatology, pedology, volcanology, hazard studies, and archaeology. Hiroshi fostered within those that have worked with him the importance of integrating diverse views, techniques and backgrounds in Quaternary research.

Researchers who have visited his laboratory have enjoyed Hiroshi's kind hospitality for both short and extended periods. They have come from many countries including Australia (Russell Blong), Canada (John Westgate), China (Liu Jiaqi), Papua New Guinea (Ben Taial), Korea (Byong-sul Lee, WongjuSoh), New Zealand (Dennis Eden, David Lowe), and the United States (Arthur Bloom, Stephen Porter, Harry Glicken). Many have gone on to be leaders in their fields.

Hiroshi's work, enthusiasm, and leadership have also helped to develop a very active and successful international grouping of tephra researchers mainly within commissions or subcommissions of INQUA. This group began as the 'International

Commission on Tephrochronology' (COT) in 1961. It ran in INQUA until 1982 when it was discontinued, having met its initial goals. COT was then effectively transferred under the umbrella of the International Association of Volcanology and Chemistry of the Earth's Interior, IAVCEI (J.A. Westgate pers. comm., 2011). However, the Quaternary tephra community re-formed the group within INQUA in 1987 at the Ottawa Congress as the 'Inter-Congress Committee on Tephrochronology' (ICCT) (see Froese et al., 2008). It became the 'Commission on Tephrochronology' (COT) in 1991, then the 'Subcommission on Tephrochronology and Volcanism' (SCOTAV) in 1995, and it has functioned as the 'International Focus Group on Tephrochronology and Volcanism' (INTAV) within the Stratigraphy and Chronology Commission (SACCOM) of INQUA since 2007. This specialist tephra group in its various guises has held inter-congress field-based meetings in a range of countries including, since 1990, USA (1990), New Zealand (1994), France (1998), Canada (2005), and Japan (2010). These specialist meetings have been career milestones for many tephrochronologists. Hiroshi has attended all the meetings from the 1980 NATO Advanced Studies Meeting in Iceland (Fig. 8) through to the most recent 'Active Tephra' INTAV meeting in Kirishima in south Kyushu, Japan, in 2010. His important contributions to this group include being vice president of ICCT in 1987-1990 and president of COT in 1991-1995. During his tenure as president, Hiroshi organized the INQUA-COT field workshop entitled 'Quaternary tephrochronology of Mt Tateyama and adjacent areas:

tephrochronological applications to alpine glaciations and environmental changes' in 1992 in Japan. Just after this (also in Japan), Hiroshi had a major input in co-organising the workshop entitled "Climatic impact of explosive volcanism" initiated and jointly sponsored by the Past Global Changes (PAGES) Core Project of the IGBP and COT in 1993 (Fig. 9). He also co-led the associated field trips to Asama volcano. In 1994 he attended the New Zealand meeting in Hamilton (Fig. 10). In Cairns, in 2007, at the INQUA Congress, Hiroshi was elected one of only four honorary members of INTAV at that time (with Andrei Sarna-Wojcicki, John Westgate, and Etienne Juvigné) in recognition of his outstanding contributions in tephrochronology. Later that year, Hiroshi was one of several key people who began planning for the 'Active tephra' meeting eventually held in Kirishima in 2010 (Fig. 11).

During Hiroshi's long service for thirty-seven years in Tokyo Metropolitan University, he was promoted to associate professor in 1968 and professor in 1982. He led and developed programmes on geomorphology and geology in Tokyo Metropolitan University with Professor Emeritus Sohei Kaizuka. After the retirement of Professor Kaizuka, Hiroshi devoted himself to educational, administrative, and academic work as the chairman of the department. Hiroshi has always engaged strongly with research-informed education. His disciplined and serious attitude to his studies deeply impressed and encouraged many students and colleagues. Hiroshi has always stressed the importance of

solid field workin learning to undertake tephra studies. Therefore, he often trained his students by taking them on excursions to the Fuji and Hakone regions wheremuch of his own research activities were undertaken. Throughout his career as an educator in the university, Hiroshi instructed and trained many students (witha strict approach) in geomorphology and Quaternary geology majors. Many of these students are now playing active parts throughout the world as leading professional engineers, scientific researchers, and teachers.

As a direct (chief) supervisor, Hiroshi has had many students –more than around 20, including eight doctoral students who mainly specialized in tephra studies: Hiroshi Moriwaki (Kagoshima University), Haruo Yamazaki (Tokyo Metropolitan University), Shinji Nagaoka (Nagasaki University), Sumiko Kubo (Waseda University), Tsutomu Soda (Institute of Tephrochronologyfor Nature and History), Takehiko Suzuki (Tokyo Metropolitan University), Kotaro Yamagata (Joetsu University of Education), and RyusukeImura (Kagoshima University).

Hiroshi retired from Tokyo Metropolitan University in March 1996, becoming professor emeritus. But, he is still officially active. The Science Council of Japan delegated him to attend the INQUA Congress in Durban in 1999. Also, he was nominated to become the president of JAQUA in 2005-2008, the vice president of the Japan Geopark Committee (2008 on), and a council member of the Science Council of Japan (2003-2005). In 2010,

Hiroshi was elected one of the honorary members of JAQUA (Fig. 12). Moreover, he published the following books: *An Illustrated Natural History of Volcanoes* (1998), *Regional Geomorphology of the Japanese Islands: Vols. 1 to 7* (2000-2006), and *Atlas of Tephra in and Around Japan (revised edition)* (2003).

Honouring and commemorating the achievements of Hiroshi, a pioneer in tephrochronology in Japan and globally, a wise, strict yet supportive mentor, and a respected leader, with this special volume seems wholly appropriate.

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### **Captions to figures**

Fig. 1. Hiroshi delivering a public lecture to a full house in Kirishima City at the start of the international 'Active Tephra' conference held in May, 2010. Photo: Koji Okumura.

Fig. 2. Hiroshi (19 years old) on Mt Kisokoma, central Japan, 1952.

Fig. 3. Hiroshi atop Mt Fuji in 1959.

Fig. 4. Field trip during the first COT meeting held at Ikuta near Tokyo, 1964. Prof.

Kunio Kobayashi (Shinshu University), the first president of COT from 1961, Professor

Emeritus Sohei Kaizuka (Tokyo Metropolitan University), and Professor Emeritus Yoko Ota

(former vicepresident of INQUA), are in this photo.

Fig. 5. Hiroshi (right) and long-time colleague Prof. Fusao Arai (1925-2004) at Gunma

University, 1977.

Fig. 6. Hiroshi (centre), Hiroshi Moriwaki and D.S. Chao undertaking fieldwork at Baegdusan (Changbai shan) volcano, China, September, 1987. The lake behind them, Tianchi (Sky Lake), lies within the summit caldera. Photo: Hiroshi Moriwaki.

Fig. 7. Hiroshi (right) examining a sequence of Holocene tephra in central New Britain Island, Papua New Guinea, December, 1988. Photo: Hiroshi Moriwaki.

Fig. 8. Hiroshi (with sample bags) on a field trip in southern Iceland at the NATO Advanced Studies Meeting in June, 1980 (see Self and Sparks, 1981). Photo: Hiroshi Moriwaki.

Fig. 9. Hiroshi (right) and Shigeo Sugihara (Meiji University) at the Past Global Changes (PAGES) and INQUA COT conference “Climatic Impact of Explosive Volcanism” held in Tokyo, December, 1993. Photo: David J. Lowe.

Fig. 10. Hiroshi (left), with Yoshitaka Nagatomo and Takehiko Suzuki alongside, taking part in a Maori action song during the INQUA COT meeting held in Hamilton, New Zealand, in February, 1994. Photo: David J. Lowe.

Fig. 11. Hiroshi (middle) with Kunihiko Endo (left) and Takaaki Fukuoka (right) on Mt Tsukuba near the venue of the JAQUA 50<sup>th</sup> anniversary “International Symposium on

Quaternary Environmental Changes and Humans in Asia and the Western Pacific”(held in Tsukuba) in November, 2007. At this meeting, planning began for the ‘Active Tephra’ INTAV meeting that was eventually held in 2010.

Fig. 12. Party to celebrate Hiroshi’s election as an honorary member of JAQUA. This event was held by some of his former students in Tokyo, August, 2010. Photo: Yoshihiko Kariya.





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