NEOGENE EVENTS IN JAPAN AND ON THE PACIFIC COAST OF SOUTH AMERICA

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ABSTRACT

By using planktonic microfossils and based upon a time-space chart of the marine molluscan faunas of Japan and a revised bio- and chronostratigraphic correlation chart of marine Neogene sequences on the Pacific coast of South America, five marine climatic and evolutionary events in both regions are discussed with reference to each other. The mid-Neogene climatic optimum seems to culminate in both regions at 16 Ma. This warm event is followed by middle Miocene cooling and upwelling events in both regions, although the predominance of diatom facies is recognized since 17 Ma in an ODP-112 core off Perú. Two warm episodes at 3 and 6 Ma are likely to be noticed in both regions. Accelerated evolutionary changes have happened in endemic mollusca of middle latitudes in both regions since 3 Ma, the outset of a Pliocene-Pleistocene cooling.

Key words: Marine Neogene, Bio-chronostratigraphy, Climatic events, Mollusca evolution, Japan, South America.

RESUMEN

EVENTOS NEOGENOS EN JAPON Y EN LA COSTA DEL PACIFICO DE SUDAMERICA. Se analizan cinco eventos marinos climáticos y evolutivos correspondientes al Neógeno de Japón y costas del oceáno Pacífico de Sudamérica. La discusión se basa en el contenido de microfósiles planctónicos, en el empleo de cartas cronoespaciales de la fauna de moluscos marinos de Japón y de una carta revisada de correlación bio- y cronoestratigráfica de las secuencias marinas. El óptimo climático del Neógeno medio parece culminar a los 16 Ma en ambas regiones. Este fenómeno cálido es seguido por el enfriamiento del Mioceno medio y los fenómenos de surgencia que tuvieron lugar en estas regiones, aun cuando se ha establecido el predominio de la facies diatomácea desde los 17 Ma en un testigo ODP-112 del Perú. Es probable que se hayan sucedido dos episodios cálidos en ambas regiones, a los 6 y 3 Ma. Con el comienzo del enfriamiento del Plioceno-Pleistoceno y a partir de los 3 Ma se produjo una aceleración de los cambios evolutivos en los moluscos endémicos de las latitudes medias de ambas regiones.

Palabras claves: Neógeno marino, Biocronoestratigrafía, Eventos climáticos, Evolución de Moluscos, Japón, Sudamérica.

INTRODUCTION

The recent progress in bio- and chronostratigraphy by utilizing planktonic microfossils enables us to make a precise chronologic succession of marine sequences and also a more precise chronologic definition of associated benthic faunas such as mollusca and larger foraminifera.

By using an improved time-space chart (Tsuchi, 1990) of the marine molluscan faunas of Japan and a revised chronostratigraphic correlation chart of marine Neogene sequences on the Pacific coast of South America, based on planktonic microfossils, an attempt is made in this paper to discuss some key Neogene events in Japan related to marine climate with reference to those on the Pacific coast of South America.

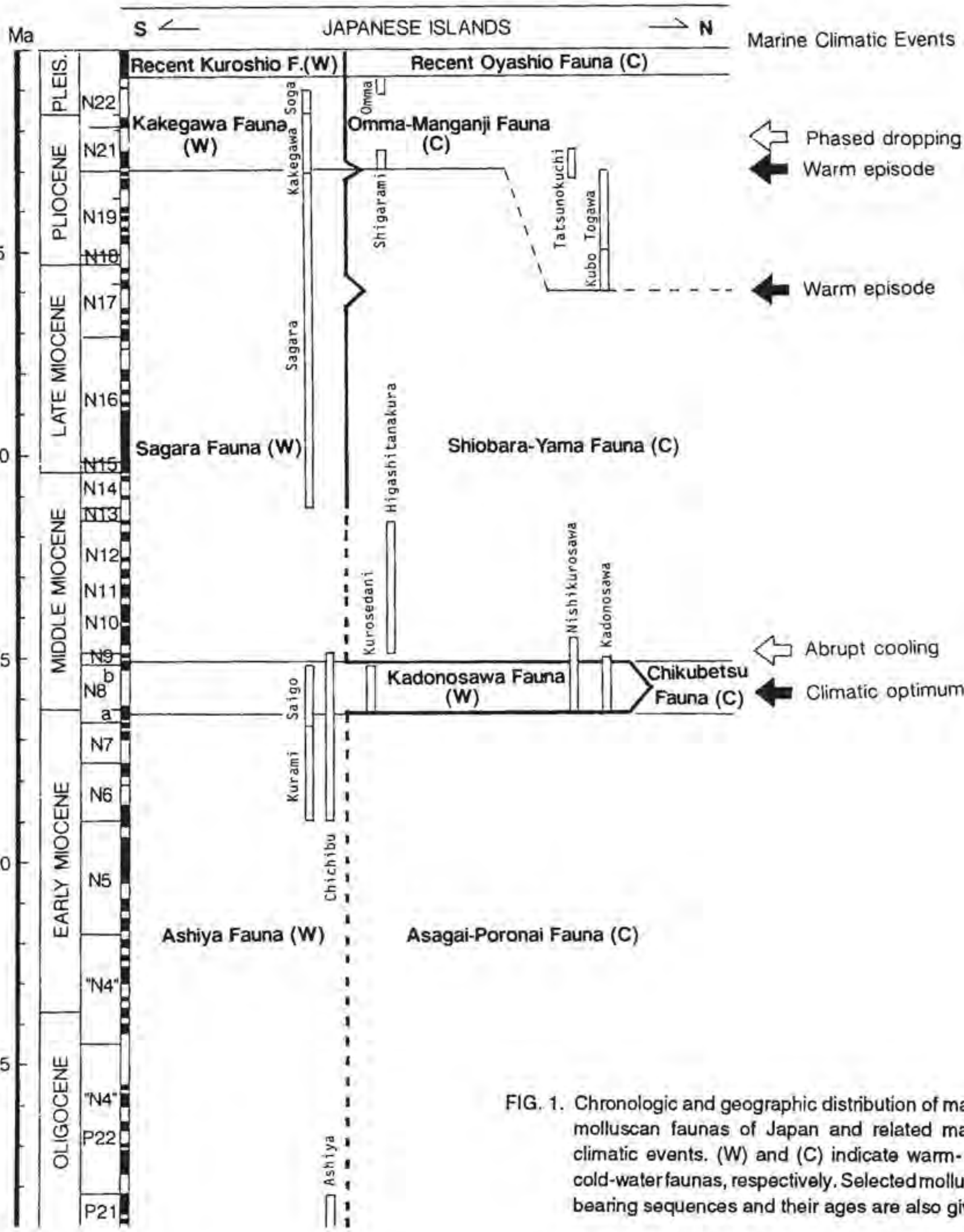

FIG. 1. Chronologic and geographic distribution of marine molluscan faunas of Japan and related marine climatic events. (W) and (C) indicate warm- and cold-water faunas, respectively. Selected mollusca-bearing sequences and their ages are also given.

NEOGENE MOLLUSCAN FAUNAS OF JAPAN IN TIME AND SPACE

Neogene marine molluscan faunas of Japan are clearly separated into warm- and cold-water assemblages as seen in the living warm Kuroshio and cold Oyashio current faunas. The chronologic and geographic distribution of marine molluscan faunas of Japan is shown in figure 1 (Tsuchi, 1990).

From the nature and distribution of these molluscan faunas in time and space, five Neogene events related to marine climate are recognized as follows (Tsuchi, 1990):

1. Mid-Neogene maximum of the seawater temperature around 16 Ma.
2. Abrupt cooling since 15 Ma.
3. Warm episode at 6 Ma.
4. Warm episode at 3 Ma.
5. Phased dropping of seawater temperature since 3 Ma and accelerated evolution of endemic forms.

These Neogene events in Japan are discussed below in relation to those on the Pacific coast of South America.

NEOGENE BIO- AND CHRONOSTRATIGRAPHY ON THE PACIFIC COAST OF SOUTH AMERICA

A revised bio- and chronostratigraphic correlation chart of selected marine Neogene sequences on the Caribbean coast of Colombia and on the Pacific coast of South America in Ecuador, Perú and Chile has been accomplished by our international collaboration works since 1985 (Tsuchi *et al.*, 1990) (Figs. 2-3). Correlations are made mainly by means of planktonic foraminifera and additionally by calcareous nannoplankton and diatoms. Based on the correlation chart, some Neogene events can be recognized on the Pacific coast of South America, as discussed below.

MID-NEOGENE CLIMATIC OPTIMUM AROUND 16 MA

This event is one of the most prominent in Japan during the earliest middle Miocene time, around 16 Ma. During this epoch, tropical and subtropical marine fauna (Fig. 1) called Kadonosawa fauna, migrated into North Japan.

The fauna includes vicarid gastropods derived originally from the Tethyan region and tropical mangrove swamp dwellers, *Telescopium* and *Geloina*. Tropical larger foraminifera, lepidocyclinids and myogypsinids, are frequently found associated with these tropical mollusca. Some kinds of pollen of mangrove swamp trees have been found in sequences of the Sea of Japan side (Yamanoi, 1984).

Most of these tropical elements are included in a limited interval of N8 and the base of N9 around 16 Ma. Based on abundant occurrences of the tropical elements in several sequences, this warm event seems to culminate in the later half of N8, or N8b at 16 Ma.

On the Pacific coast of South America, sequences assignable to N8-9 are frequently found in places as seen in the Dos Bocas Member of the San Vicente section and the Jaramijo section in Ecuador, the Camaná section at Camaná in Perú, and the Caleta Herradura de Mejillones section, north of Antofagasta in Chile, where they have abundant and diverse warm water planktonic foraminifera (Tsuchi, 1990; Ibaraki, 1990; Martínez-Pardo, 1990). In the Peruvian Neogene sequences diatom facies are predominant, probably due to cold ocean currents and coastal upwellings (Koizumi, 1991). However, miogypsinids occur abundantly in calcareous sandstone of the

FIG. 2. Distribution of marine Cenozoic strata on the Pacific coast of South America and Caribbean coast of Colombia (areas in black).

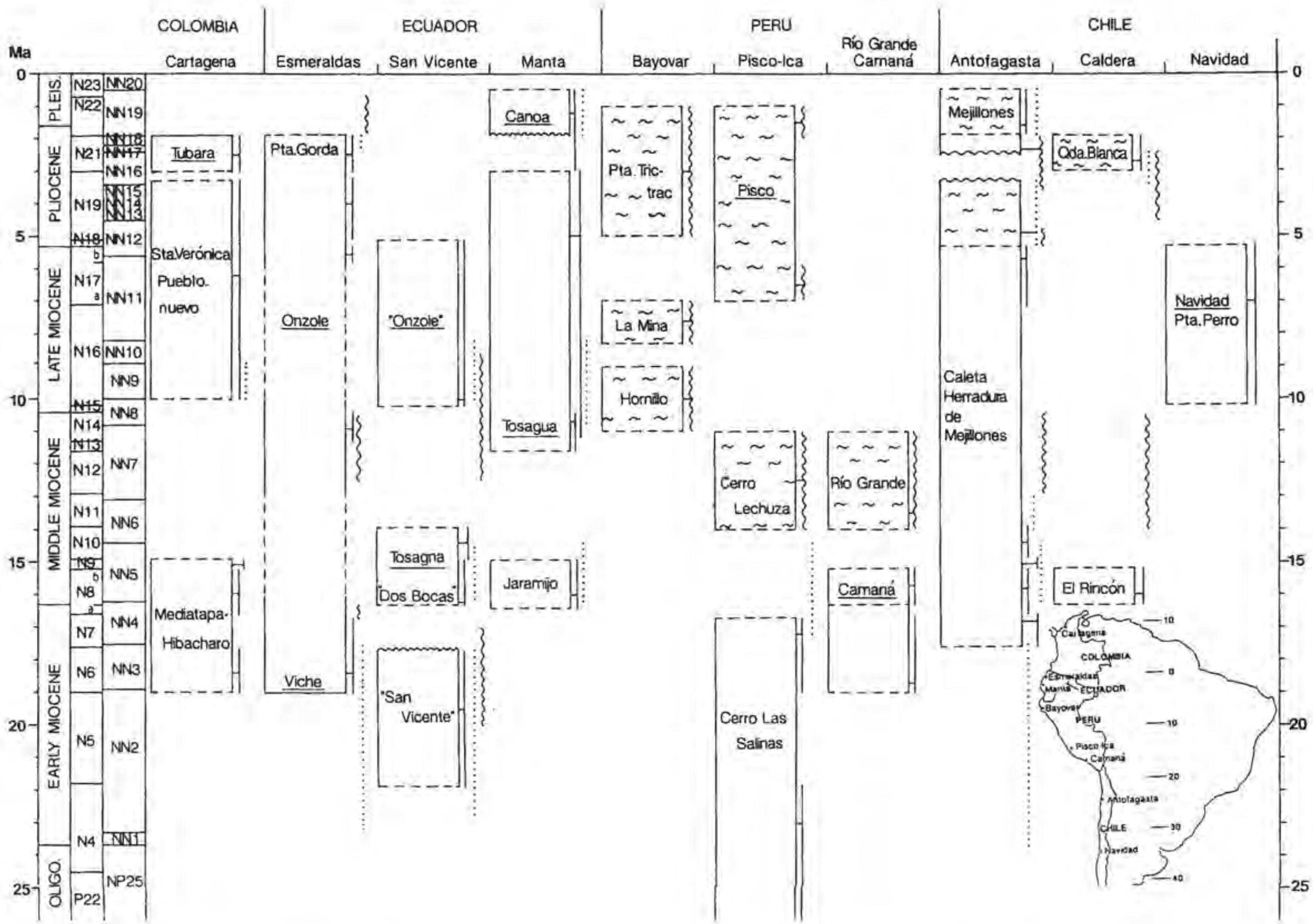

FIG.3. Revised bio- and chronostratigraphic correlation chart of selected marine Neogene sequences on the Pacific coast of South America and the Caribbean coast of Colombia.

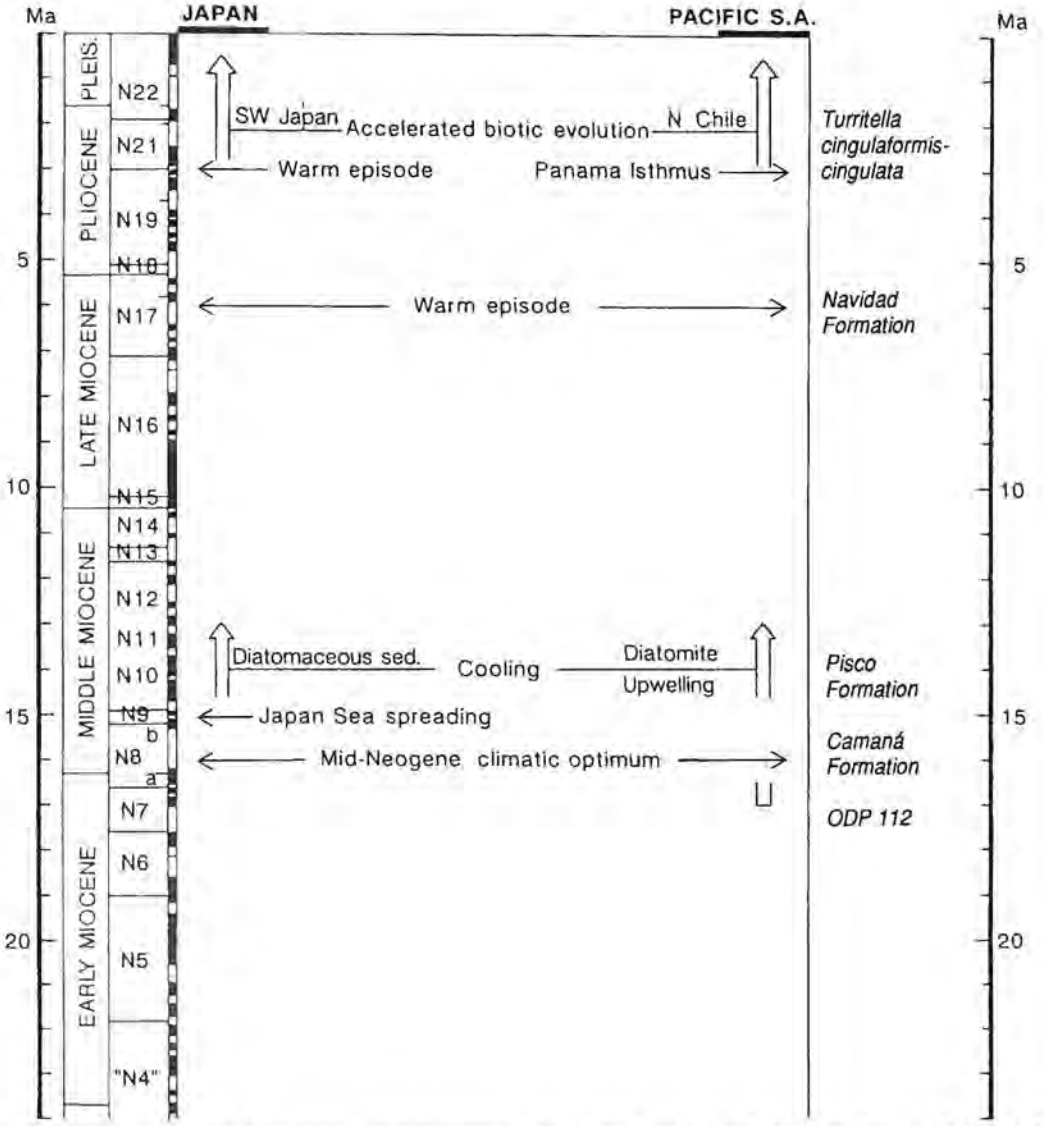

FIG. 4. Pacific Neogene events in Japan and South America related to marine climate. Related sections and fossils in South America are also given on the right side.

Camaná Formation at Camaná, southern Perú, which is assigned to N8b at 16 Ma by means of planktonic foraminifera (Tsuchi, 1990).

MIDDLE MIOCENE COOLING AND UPWELLING EVENTS

The mid-Neogene climatic optimum is followed by an abrupt cooling beginning at 15 Ma. The warm water Kadonosawa fauna changed abruptly to the cold water Shiobara-Yama fauna by the later part of N9 in central and northern Japan and to the Sagara fauna in southern Japan (Fig. 1), although the early part of the Sagara fauna is missing due to a regional unconformity. Diatomaceous sediments become predominant especially in sequences of the Sea of Japan side and northern Japan.

In Perú, a middle Miocene cooling of the seawater temperature is recognized by the predominance of biosiliceous facies in the Río Grande section and the Pisco Formation, which are assignable to middle Miocene to Pliocene in age by means of diatoms. Studies of the ODP-112 cores off Perú reveal, however, that diatomaceous facies prevail above N6-7, or in NN4 at 17 Ma (Ibaraki, 1992; Fig. 4). A hiatus in diatom facies below NN6 (Suess and von Huene *et al.*, 1988) may suggest a warm episode represented by the Canamá Formation.

LATE NEOGENE WARM EPISODES

Two successive warm episodes at 6 Ma and 3 Ma are known from abundant occurrences of tropical-subtropical mollusca in respective horizons on the Pacific coast of central Japan.

In Chile, the Punta Perro section of the Navidad Formation at Navidad is assignable to N16-17 probably at 6 Ma, according to Japanese studies (Fig. 4) and contains numerous tropical mollusca and warm water planktonic foraminifera (Covacevich and Frassinetti, 1983; Ibaraki, in press). Horizons of the Caleta Herradura de Mejillones section near Antofagasta, being assignable to N17 at 6 Ma, also include abundant and diversed planktonic foraminifera (Ibaraki, 1990). This warm 6 Ma event, likely to be noticed simultaneously in both regions, is not in agreement with the micropalaeontological ages assigned to the above sequences in Chile, however (Martínez-Pardo, 1990).

Sequences assignable to 3 Ma in age are the fossiliferous Tubara Formation in northern Colombia, the Punta Gorda section near Esmeraldas in Ecuador and the onset of the diatomite deposition in northern Chile (Tsuchi *et al.*, 1990). A warm episode at 3 Ma recognized in Japan is considered to have a possibility relating to reinforced warm currents caused by the complete emergence of the Isthmus of Panamá at 3 Ma. However, disclosing interrelations between these horizons in South America and a warm episode in Japan at 3 Ma is a problem that remains to be solved, though it would be present in Chile (Martínez-Pardo, 1990).

ACCELARATED EVOLUTION OF ENDEMIC FORMS SINCE 3 MA

Among the Pliocene-Pleistocene Kakegawa fauna on the Pacific coast of central and southwestern Japan an endemic bioseries of *Suchium suchiense (Yokohama)* has demonstrated accelerated evolutionary changes in shell form during the period 3-1 Ma. *Suchium suchiense* subsp. A, appearing at 3 Ma successively evolves through *S. suchiense* s.s., *S. suchiense subsuchiense* (Makiyama) and *S. giganteum naganumanum* (Otuka) to the Recent species, *S. giganteum* s.s., at 1.6 Ma (Tsuchi, 1986). Timing of the evolutionary changes recognized here seems to be closely related to phased dropping of the seawater temperature since 3 Ma (Tsuchi, 1990).

On the Pacific coast of northern Chile, an endemic form, *Turritella cingulata* (Sowerby), is now living in a shallow sandy bottom. In the Quebrada Blanca section near Caldera, specimens of the *T. cingulatiformis-cingulata* bioseries are successively found upwards, their spiral cords having gradually changed from *T. cingulatiformis* (Möricke) at 3 Ma to *T. cingulata* (Sowerby) in the high terrace deposits probably at 0.3 Ma. Such accelerated evolutions are considered to be typically found in middle latitude areas.

CONCLUSION

Based upon a chronologic and geographic distribution of marine Neogene molluscan faunas of Japan and a revised chronostratigraphic correlation chart of marine Neogene sequences on the Pacific coast of South America by means of planktonic microfossils, five marine climatic events in both regions are discussed with reference to each other (Fig. 4).

The mid-Neogene climatic optimum seems to culminate in both regions at 16 Ma as seen in abundant planktonic foraminifera-bearing horizons in Ecuador and Chile, and in *Miogypsina*-bearing horizons of the Camaná Formation in southern Perú.

The climatic optimum is followed by middle Miocene cooling and upwelling events represented by prevailing diatomite facies in Perú, although diatomite facies become predominant since 17 Ma in an ODP-112 core off Perú.

Of the two successive warm episodes recognized in Japan at 6 Ma and 3 Ma, the former event would be represented by the Punta Perro section of the Navidad Formation and in the Caleta Herradura de Mejillones section near Antofagasta.

Accelerated evolutions are found in the bioseries of endemic mollusca, *Turritella cingulatiformis-cingulata* in northern Chile since 3 Ma. These quick evolutionary changes in endemic forms are considered to be characteristic in middle latitude areas as recognized in northern Chile and Japan.

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