GLACIAL STRATIGRAPHY OF ANTARCTICA AND OF THE NORTHERN JAPANESE ALPS: A THEORETICAL CLIMATESTRATIGRAPHIC COMPARISON FOR THE PERIOD 4000–2000 y B.P. BASED ON RADIOCARBON DATING (EXTENDED ABSTRACT)

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1. Introduction

The Quaternary geological thinking is dominated these days by "localism". This is nothing but a natural reaction to the flourishing but too simplistic doctrine by PENCK and BRÜCKNER (1909) which has spread all over the world during the first half of the century. Of course, there are exceptions to this rule, as published by DENTON and HUGHES (1981) or SIBRAVA (1974 and since). But still, far-reaching 1st order correlations (RUTSCH, 1958) are not possible yet due to too many uncertainties in stratigraphic knowledge, nomenclature and classification. Large-scale correlations of Pleistocene events especially between the Northern and Southern Hemispheres are still ambiguous and discussed with doubt.

Also with this communication we are not going to present a scheme of correlations between the glacial records of Antarctica and the Northern Japanese Alps; but we would like to stress the importance of comparing the glacial stratigraphy of two very different areas in the Northern and Southern Hemispheres which are both so sensitive to climatic changes.

In addition, we would like to encourage the checking of existing working hypothesis and stimulate further comparative research. This communication is mainly the result of a combination of several "lucky events" which have enabled the first author to do field work and to look at the problems discussed here *in situ*: that is in the Japanese Alps (1979, 1981) as well as in Antarctica (1981/82). With the stratigraphic results of our first expedition to the Northern Japanese Alps in 1979 we have been quite puzzled to find radiocarbon-age-evidence for a young mountain glaciation after 2600 ^{14}C-y B.P. This result shall be discussed now in a north/south Pacific context.

2. The Antarctic Glacial Record

The results of detailed investigations by Prof. G. DENTON, University of Maine (USA) in the McMurdo Sound area and in the Dry Valleys sector of the Transantarctic Mountains give evidence that there are three types of glacier fluctuations in Antarctica (DENTON and HUGHES, 1981):

(1) The fluctuations of the large outlet glaciers draining the East Antarctic Ice Sheet through valleys in the Transantarctic Mountains (*e.g.* Drygalski and Nordenskjøld Ice Tongues, Taylor, Koettlitz, Byrd and Nimrod Glaciers).

(2) The fluctuations of the large ice shelves (Ross, Ronne and Filchner Ice Shelves).

(3) The fluctuations of the alpine glaciers in the Dry Valleys sector of the Transantarctic Mountains; typically developed in the Asgard Range between Taylor and Wright Valleys.

Both the fluctuations of the ice shelves and the large outlet glaciers are responding to the mass balance evolution and the dynamics of the Antarctic Ice Sheets, whereas the fluctuations of the alpine glaciers in the Transantarctic Mountains are ice-sheet independent.

Well-documented results by DENTON and HUGHES (1981) demonstrate the interaction between the fluctuation of the two "glacier systems": during periods of global cooling (and Northern Hemisphere glaciations) the Ross Ice Shelf becomes grounded due to sea level lowering and the ice advances over the continental shelf and well into the lower parts of the Dry Valleys, thus damming large freshwater lakes there. The highest lake levels are considered to mark the full glacial maximum dated at 17000 to 21000 y B.P. (DENTON and HUGHES, 1981). The critical factors controlling these mechanisms are the lowering of the sea level and the resulting readjustment of the grounding line for the "advancing ice sheet".

In contrast to the fluctuations of the ice shelves are the oscillations of the locally fed alpine glaciers. Their mass balance is controlled by the availability of moisture to the central parts of the Transantarctic Mountains. It means that a more open Ross Sea (=corresponding to global interglacial climatic conditions) will increase precipitation there and initiate an advance of the local alpine glaciers. On the other hand, further extension of the Ross Ice Shelf towards the Pacific Ocean closes the source for moisture to the Transantarctic Mountains (=corresponding to global glacial conditions) which causes shrinking of the local alpine glaciers. The relationships between the lithogenetic effects of an advancing Ross Ice Shelf into lower parts of the Dry Valleys and of oscillating local glaciers is well documented in the Taylor Valley. There it can be observed that the deltas formed in lakes during the maximum of the Last Glaciation have been overridden since by local alpine ice tongues (DENTON and HUGHES, 1981:347).

In the following we are focusing on this most recent advance of the local alpine glaciers as it has been one of the main subjects for our fieldwork during the last austral summer. All the investigated alpine glaciers so far exhibit one common lateral morainic feature: a well-developed mostly ice-cored moraine. It may consist of a boulder line only but may reach quite voluminous dimensions of up to

10 m in height as well. Towards the snout of the glacier this moraine ridge disappears underneath the ice. At several localities the young ice-cored lateral moraine has been dated: at places where algae-beds on submerged deltas are reworked into the moraine sediments maximum ages for the readvance can be obtained (DENTON and HUGHES, 1981). With this sampling method the last readvance of the local alpine glaciers could be dated at approximately 2900 to 3000 ^{14}C-y B.P. This event reflects a young "relative maximum" of the local Transantarctic ice in thickness (?) and lateral extent. Since then, the ice has melted back from this lateral position and thinned-out somewhat, while frontal parts are continuing to advance.

3. The Glacial Record in the Northern Japanese Alps

During our expeditions to the Northern Japanese Alps of 1979 and 1981 three key-sections have been discovered which are of regional importance: (1) the fossil Kitamata Gorge in the Matsukawa–Kitamata–Mt. Shirouma area, (2) the Raicho Plateau at Murodo/Tateyama and (3) the Shomyo River at Tateyama-renpo Lodge (SCHLÜCHTER *et al.*, 1981a, b). These sections are important because the uppermost parts of genetically complicated lithostratigraphies contain organic deposits interbedded with glacigenic sediments.

(1) The fossil Kitamata Gorge section exhibits a complex set of tills corresponding to different glaciations with interbeded fossil soils. The recent topsoil is developed on a distinct basal till which itself rests on a strongly developed paleosoil on an older till. This paleosoil has yielded a ^{14}C-age of 3795±75 y B.P. (CS-J-42=UZ-322).

(2) The Raicho Plateau section (Fig. 1) at Murodo/Tateyama is the most complete but also the most complicated Pleistocene sedimentary succession so far described from the Japanese Alps. Its uppermost part is of complex genetic interrelationships between glacigenic, volcanoclastic and organic deposits (for detailed description see: HORIE *et al.*, 1981). The most important units are two layers of

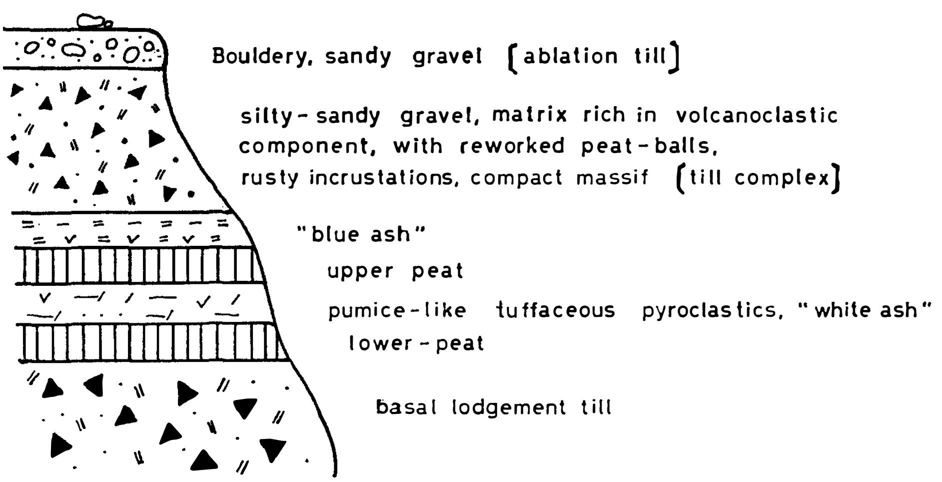

Fig. 1. Schematic section of an outcrop of glacigenic deposits in Tateyama Mida-ga-hara.

fossil peat overlain by glacigenic sediments.

The overlaying sediments (= top layer of the section) are considered to be glacigenic on the basis of their textural composition, high bulk density ("compactness") and the typical fissility. It is quite possible that they are affected by later eruptions in the Mikurigaike crater (causing "rusty incrustations").

Towards the Murodo terminal the abundance of rusty incrustations decreases and the topsoil becomes more and more the typical basal lodgement till. The radiocarbon age determinations for the peats are:

upper bed: 2625±70 y B.P. (CS-J-51 = UZ-326)
lower bed: 4025±75 y B.P. (CS-J-50 = UZ-325).

(3) The Shomyo River section at Tateyama-renpo Lodge exhibits a similar lithogenetic development as at Raicho Plateau. Again it is a complex set of glacigenic, volcanoclastic and organic deposits with the same succession for the top units as mentioned from the Raicho Plateau. Here too, two fossil peat layers are present, separated by fluvioglacial/fluvial gravelly sands and volcanoclastics. Of interest for this discussion are again the radiocarbon age determinations on the peat samples:

upper bed: 2750±60 y B.P. (CS-J-47 = UZ-323)
lower bed: 3875±70 y B.P. (CS-J-48 = UZ-324).

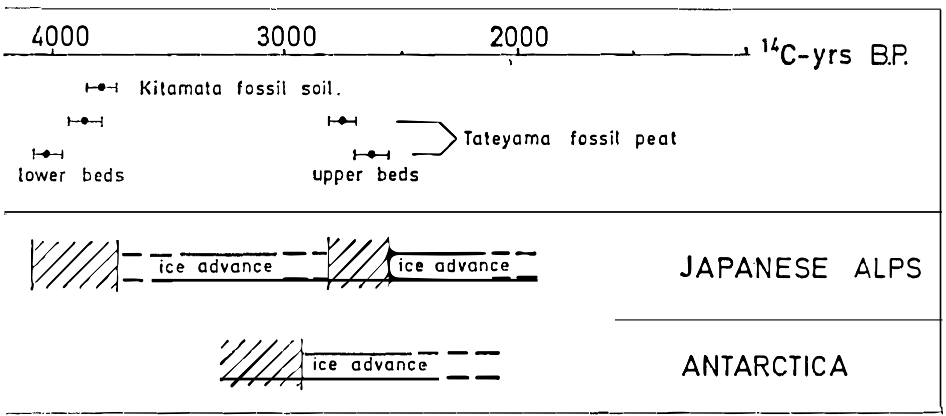

Fig. 2. Climatestratigraphic interpretation of radiocarbon dated organic deposits between tills from the Japanese Alps and comparison with the most recent local alpine ice advance in the Transantarctic Mountains (shaded areas represent minimal ice free periods).

The climatestratigraphic importance of the sections mentioned from the Japanese Alps is, first, in their ^{14}C-time calibration and, second, in their lithogenetic documentation: they point to two relatively young glacial advances, separated by ice-free periods (Fig. 2). A build-up of a mountain glaciation in the Japanese Alps is possible only if enough precipitation is delivered to the area from the Sea of Japan by westerly/northwesterly winds combined with a (only slight) lowering of the snow line (= Northern Hemisphere cooling). The Northern Japanese Alps are considered to be sensitive with regard to the initiation of a glaciation as under the present climatic conditions perennial snow patches (and permafrost) exist. A slight global climatic cooling causes a lowering of the snow line in the Japanese Alps; this results in the growth of glaciers at higher altitudes even without increase in snowfall (NOGAMI *et al.*, 1980).

4. Discussion and Summary

The climatestratigraphic importance of the two short glacial records discussed in the Pacific region is given by the opposed mechanisms to cause local glaciers to advance: (a) Cooling (global?) causes a lowering of the snow line in Japan and a growth of glaciers is initiated. (b) Warming (global?) gives origin to more open water in the Ross Sea (and the entire Antarctic oceans) and therefore a higher rate of precipitation is available to the Transantarctic Mountains. This situation causes the local alpine glaciers to grow there. The local glaciers' growth in Japan and Antarctica are caused by opposite global climatic trends, following this reasoning.

This means in Denton's stratigraphic classification (DENTON and HUGHES, 1981) that the local alpine glaciers of the Transantarctic Mountains are in an out-of-phase response to the general global trend: they advance when the Southern Hemisphere (only?) is affected by a general warming trend.

If we examine Fig. 2 then we realize that the stratigraphic knowledge discussed here shows the out-of-phase character of the northern and southernmost Pacific local glacier advances in their completely different climatic setting. After the results presented in Fig. 2 it can be deduced that the local Transantarctic alpine glaciers started to advance when ameliorated climate enabled the growth of peat in the Japanese Alps, under climatic conditions similar to the present. If the subsequent shrinking process as evidenced by the abandonment of the youngest lateral ice-cored moraine of the Transantarctic alpine glaciers has been initiated by the later cooling (evidenced by ice advance in Japan, Fig. 2) it is not documented by radiometric dating yet.

One important methodological question still remains open: the most recent readvance of the Transantarctic alpine glaciers is about 300 radiocarbon years older than the most recent glacial event of our radiocarbon stratigraphy in the Japanese Alps. The problem is therefore, if this time gap of ± 300 ^{14}C-y only is proof enough for an out-of-phase behavior of the southernmost Pacific local glaciers or if not both advances (in Japan and in Antarctica) are in fact of the same age and therefore in a climategenetic sense caused by the same global trend. This transpacific climatestratigraphic comparison leads to the following general remarks:

(1) The radiocarbon age determinations on fossil soils and peat from the Northern Japanese Alps are presumably not a local anomaly. They indicate in their lithostratigraphic setting glaciation and climatic fluctuations shortly after 4000 and between 3000 and 2600 ^{14}C-y B.P. Furthermore, the lithostratigraphic successions at Tateyama can be considered as reference-sections for the northwestern Pacific region. However, the radiocarbon dates obtained so far are in contrast to the pedogenetic evolution of the top and paleosoils in the sections sampled. The soils indicate that the radiocarbon dates from Japan might be too young.

(2) The most recent readvance of the local Transantarctic alpine glaciers is well dated also by the radiocarbon method. For the local alpine glacial advances in Antarctica an out-of-phase chronology with the Northern Hemisphere events is proposed by DENTON and HUGHES (1981). This means that there is a unique opportunity to check this hypothesis for the most recent glacial advance by continuing our research and by focusing on a more precise dating of the lithostratigraphic successions both in Japan and Antarctica.

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