DISTRIBUTION AND ORIGIN OF EVAPORITE MINERALS FROM DRY VALLEYS, VICTORIA LAND

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***Abstract*:** Evaporite minerals collected from the Dry Valleys region of Victoria Land were studied with X-ray diffraction analyses. Calcite, aragonite, monohydrocalcite, thermonatrite, trona, thenardite, gypsum, halite, sylvite, soda niter, bloedite, darapskite, and burkeite were identified in specimens from the ground surface, and calcite, fluorite, laumontite, chabazite, antarcticite, and chlorite in core samples.

In general, carbonate minerals predominate in the Taylor Valley, while sulfate minerals, except thenardite, predominate in the Wright Valley. Halite and thenardite are widespread in both areas. Trona and thermonatrite are found exclusively in the eastern Taylor Valley, and soda niter, bloedite, and darapskite in the Wright Valley. From the comparison of the salts distribution and the chemical composition of lake water, it seems that the main sources of salts distributed in the Taylor Valley and the Wright Valley are of marine and/or air-borne origins, and a small amount of salts in core samples came from hydrothermal solution.

1. Introduction

The Dry Valleys region of Victoria Land in Antarctica is well-known a a district in which occur evaporite minerals on the ground surface (*e.g.* MORIKAWA *et al.*, 1975; WATANUKI and MORIKAWA, 1975). X-ray diffraction analyses were carried out on about 450 specimens of evaporite minerals collected in the region during the 1974–1975 season. Based on the data reported in the previous work (NISHIYAMA and KURASAWA, 1975) and the chemical composition of lake water, distribution and origin of evaporite minerals in the Dry Valleys region are discussed in this paper.

2. Occurrence

The Dry Valleys region measures approximately 80 km from north to south, 60 km from east to west, containing three ice-free U-shaped valleys, Victoria Valley, Wright Valley, and Taylor Valley. Higher areas are covered with ice.

As shown in Fig. 1, evaporite minerals were taken from the Taylor Valley,

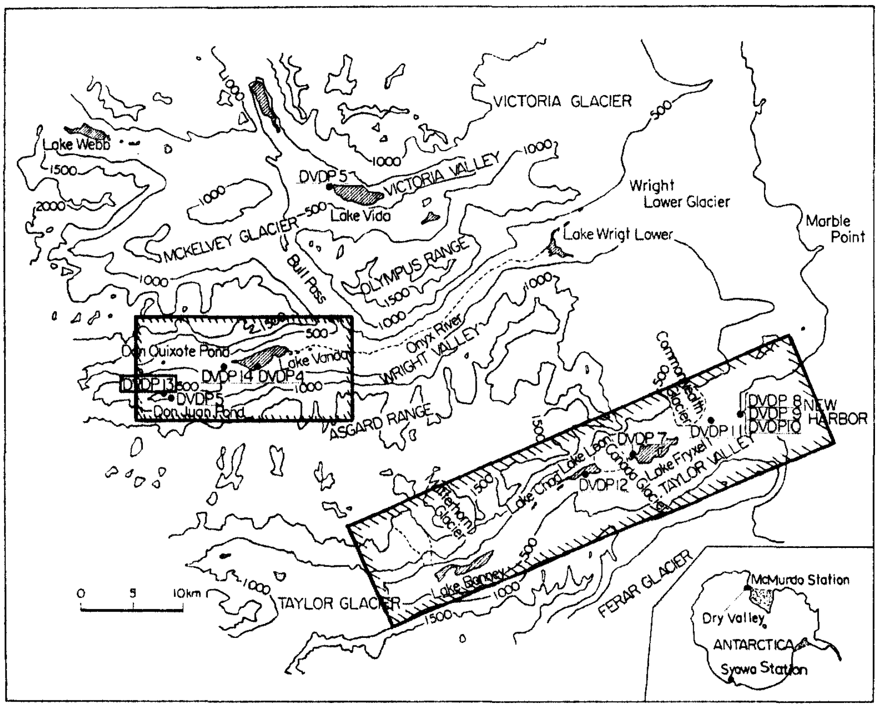

Fig. 1. Topographic map of the Dry Valleys region showing the Taylor Valley and the western part of Wright Valley, and the location of hole DVDP 13.

from the western part of the Wright Valley, and from hole DVDP 13. Most of the evaporite minerals on the ground occur as a powder or a mineral coating the surface or undersurface of pebbles (Fig. 2). In the cores they have been formed by deposition on fracture surfaces or by sediments at the bottom of Don Juan Pond. Their colors are white, brown, or yellow ocher.

3. X-ray Study

X-ray study was made in laboratories of McMurdo Station and of Kyoto University at room temperature. Halite (NaCl), thenardite (Na_2SO_4), gypsum ($CaSO_4 \cdot 2H_2O$), calcite ($CaCO_3$), thermonatrite ($Na_2CO_3 \cdot H_2O$), and trona ($NaHCO_3Na_2CO_3 \cdot 2H_2O$) were identified in many specimens from the ground surface, and soda niter ($NaNO_3$), bloedite ($Na_2Mg(SO_4)_2 \cdot 4H_2O$), darapskite ($Na_3(NO_3)(SO_4) \cdot H_2O$), aragonite ($CaCO_3$), sylvite (KCl), monohydrocalcite ($CaCO_3 \cdot H_2O$), and burkeite ($Na_6(CO_3)(SO_4)_2$) in a few specimens. The X-ray powder patterns of some rare minerals among them are given in Fig. 3a. Trona always coexists with thermonatrite, and bloedite often with darapskite. Burkeite, found with thermonatrite and trona, is a solid solution between Na_2SO_4 (thenardite) and Na_2CO_3 (thermonatrite).

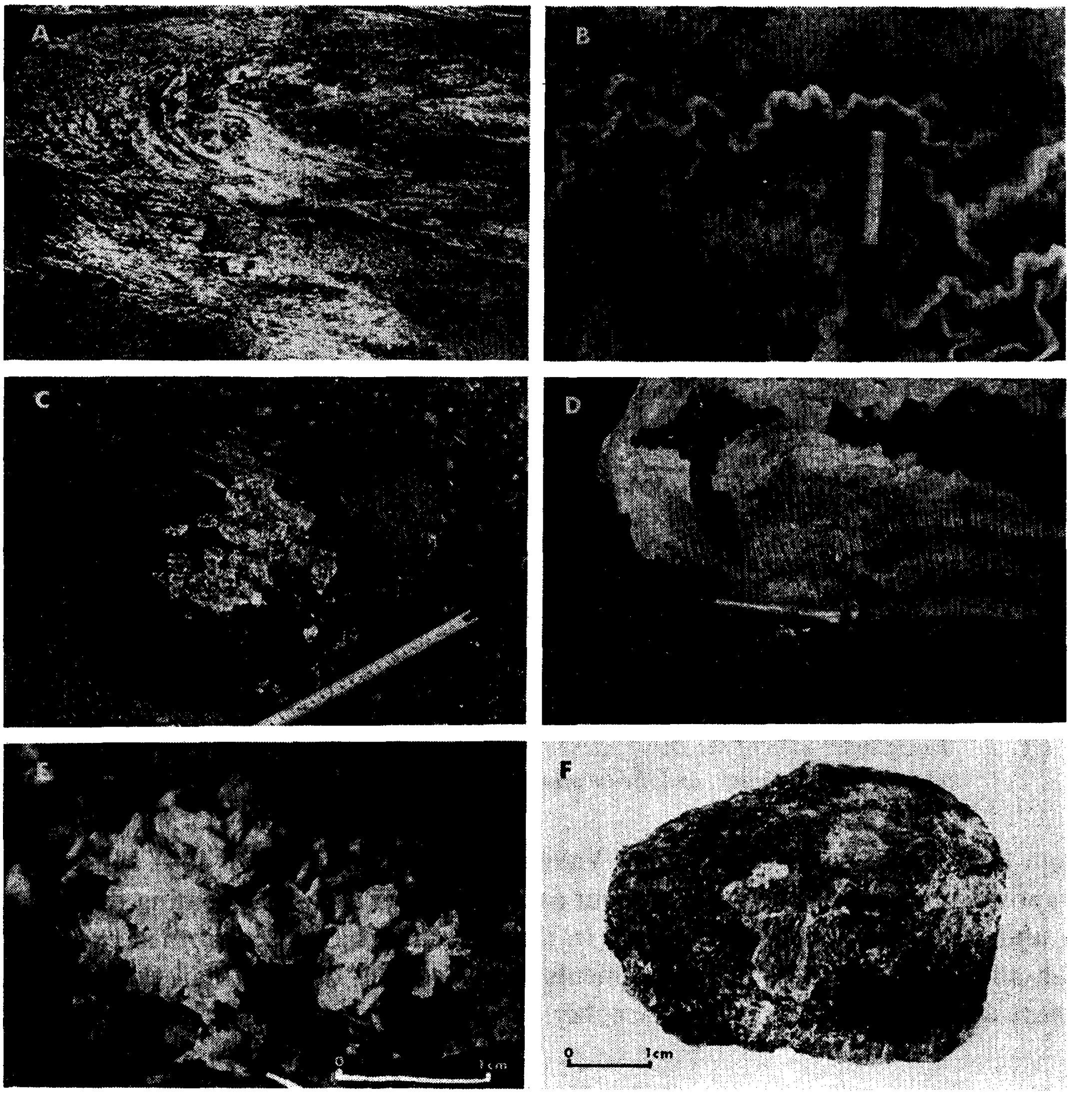

Fig. 2. Evaporite minerals observed at the Taylor Valley and the western part of the Wright Valley.

A: Thermonaterite and trona (near the Commonwealth Glacier)

B: Halite (at Don Juan Pond)

C: Calcite (at the Taylor Valley)

D: Aragonite (at the western part of the Taylor Valley)

E: Crystals of gypsum (at the Wright Valley)

F: Fluorite and calcite (in hole DVDP 13)

Calcite, fluorite (CaF_2), laumontite, chabazite, antarcticite ($CaCl_2 \cdot 6H_2O$), and chlorite were identified in hole DVDP 13 (Fig. 3b).

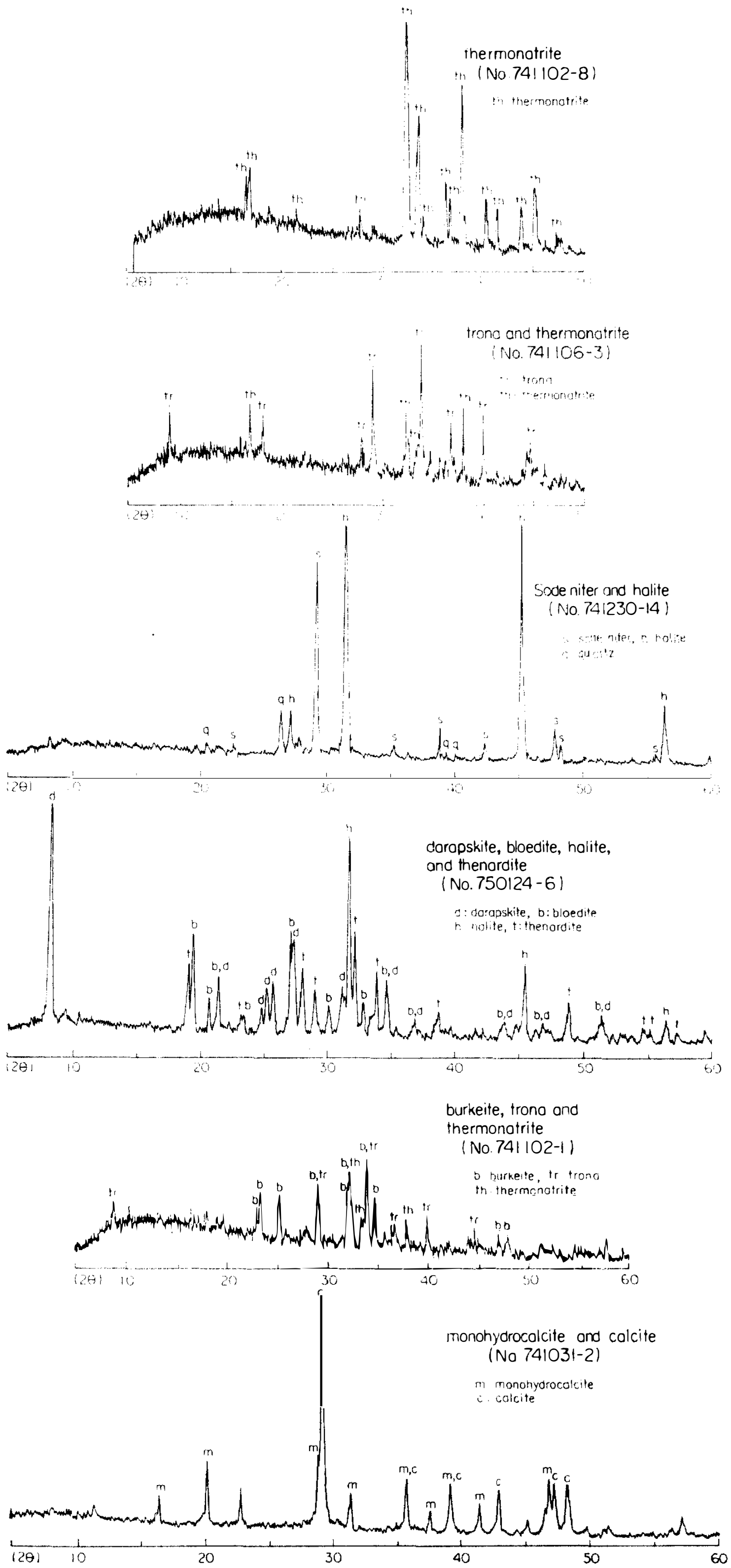

Fig. 3a. X-ray powder diffraction patterns of some rare minerals from the ground surface.

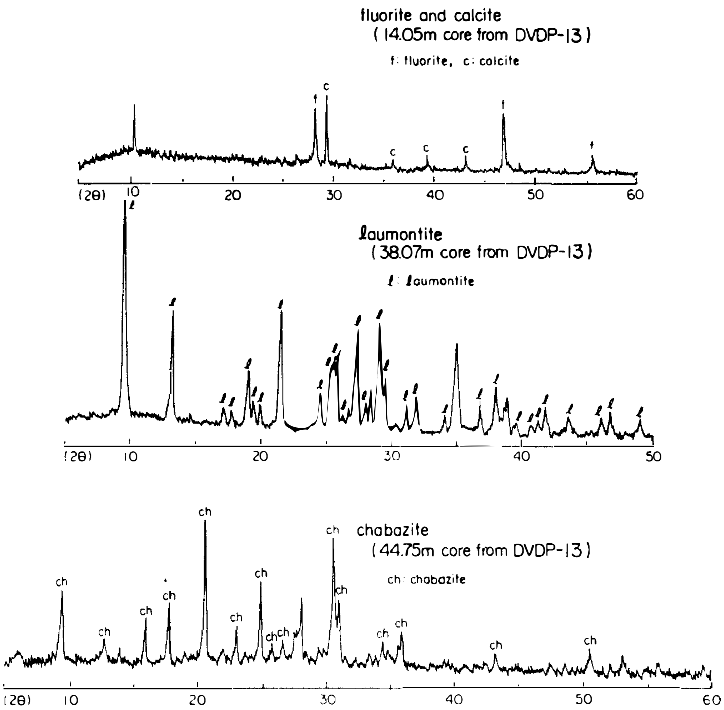

Fig. 3b. X-ray powder diffraction patterns of secondary minerals from hole DVDP 13.

4. Distribution of Evaporite Minerals on the Ground Surface

Carbonate salts and double salt containing carbonate: In general, carbonate minerals are more predominant in the Taylor Valley than in the Wright Valley. Calcite is abundant and widespread throughout the both valleys, while aragonite that has the same chemical composition as calcite, is not abundant and present in the western Taylor Valley (Fig. 4a). Trona, thermonatrite, monohydrocalcite, and burkeite are found exclusively in the eastern Taylor Valley (Fig. 4b).

Sulfate salts: Thenardite and gypsum are ordinary minerals in both areas (Fig. 4c). Thenardite may be formed initially from mirabilite ($Na_2SO_4 \cdot 10H_2O$) *in situ* or in laboratories, so in this paper mirabilite is described as thenardite. Thenardite (mirabilite) is uniformly distributed and gypsum is concentrated in the Wright Valley. Distribution of bloedite identified in four specimens is restricted to the Wright Valley (Fig. 4d).

Nitrate salt and double salt containing nitrate: Soda niter and darapskite are not abundant and their distribution is limited in the Wright Valley (Fig. 4d). It is interesting that they contain nitrate ion and/or magnesium ion.

Chloride salts: Halite is the most abundant and ubiquitous mineral in the areas. Sylvite occurs in a small amount around the shores of Lake Chad, Lake

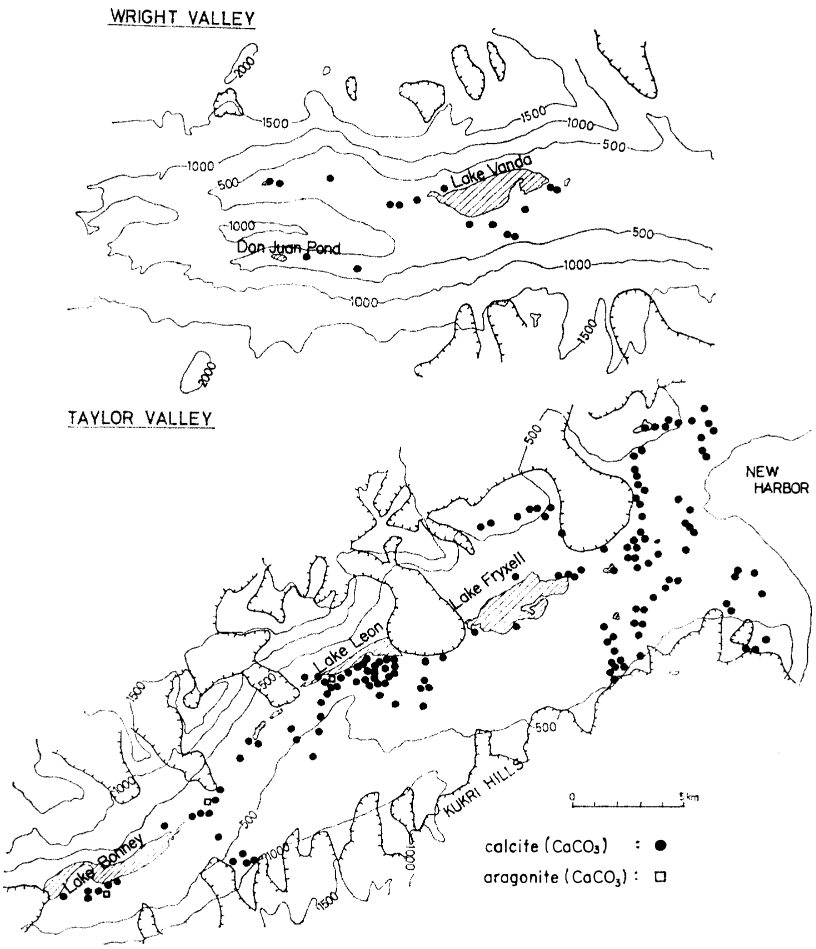

Fig. 4a. Calcite and aragonite.
Fig. 4 (a–e). Distribution of evaporite minerals.

Fryxell and Lake Vanda (Fig. 4e).

5. Distribution of Secondary Minerals in Hole DVDP 13

DVDP 13 was drilled on the shore of Don Juan Pond. 75 m of core consisted of 13 m sediments and 62 m basement rocks. About 50 specimens taken from the core were examined. As shown in Fig. 5 gypsum occurs in sediments, and laumontite, chabazite and fluorite that have not occurred on the ground surface are found. The most abundant mineral is calcite (Fig. 5).

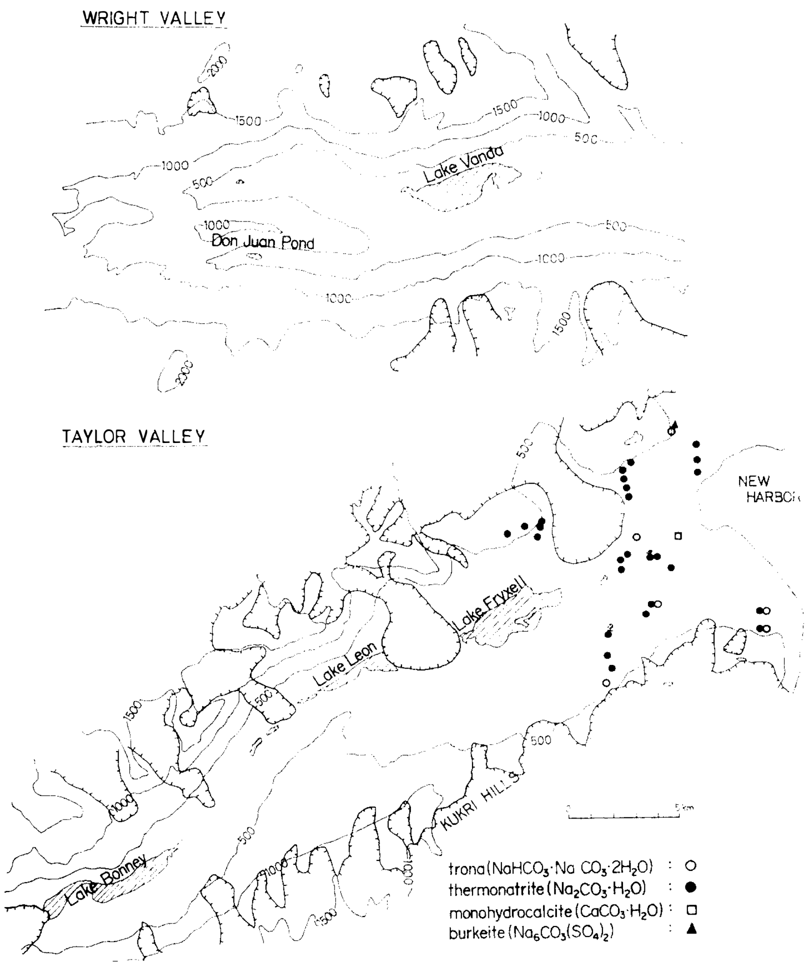

Fig. 4b. Trona, thermonatrite, monohydrocalcite and burkeite.

6. Origins of Evaporite Minerals

Various sources of evaporite minerals widely distributed in the Dry Valleys region (*e.g.* marine, air-borne, rock weathering, and hydrothermal origin) have been discussed. Studies of the chemical composition of lake water (*e.g.* YAMAGATA *et al.*, 1967) reveal that Ca^{2+} is enriched in Don Juan Pond and Lake Vanda in the Wright Valley, Mg^{2+} and Na^{+} in Lake Bonney in the Taylor Valley, and Na^{+} in Lake Fryxell in the Taylor Valley. Abundant Cl^{-} content and a small amount of SO_4^{2-} are found in Lake Bonney and Lake Vanda. In Lake Fryxell, they also occur with a significant amount of HCO_3^{-} (Fig. 6). Comparing the distribution of evaporite minerals with the chemical composition of lake water, it was observed that major elements in evaporite minerals were not always abundant elements in lake water. For example, SO_4^{2-} content shows higher values in lake water of the Taylor Valley than those

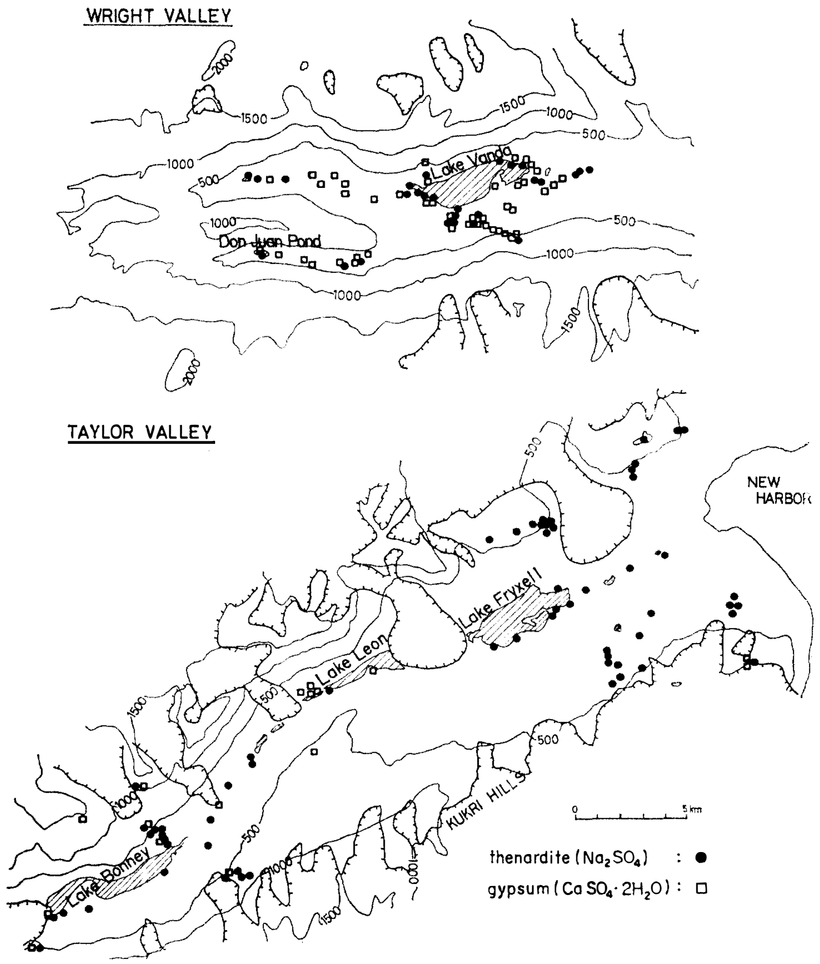

Fig. 4c. Thenardite and gypsum.

of the Wright Valley, while sulfate salts (*e.g.* gypsum) concentrate in the Wright Valley. This fact suggests that the chemical composition of lake water is not ascribed mainly to the leaching of evaporite minerals.

The order of deposition in the evaporation of sea water is $CaCO_3$—$CaSO_4$—$NaCl$—($MgSO_4$) and the resultant brine contains large quantites of $MgCl_2$ and $MgSO_4$. When sea water is concentrated under frigid conditions, however, the order of deposition of salts is ($CaCO_3$)—$Na_2SO_4 \cdot 10H_2O$—$NaCl \cdot 2H_2O$—potassium and magnesium salts (and probably $MgSO_4$), and the remaining brine is composed of calcium chloride in a large proportion (THOMPSON and NELSON, 1956). In the Dry Valleys, both types of deposition have probably occurred. During summer the former type is more important than the latter, whereas in winter the latter becomes more effective. Moreover, there are differences of topographical and meteorological conditions between the two valleys. In the Taylor Valley there is a small

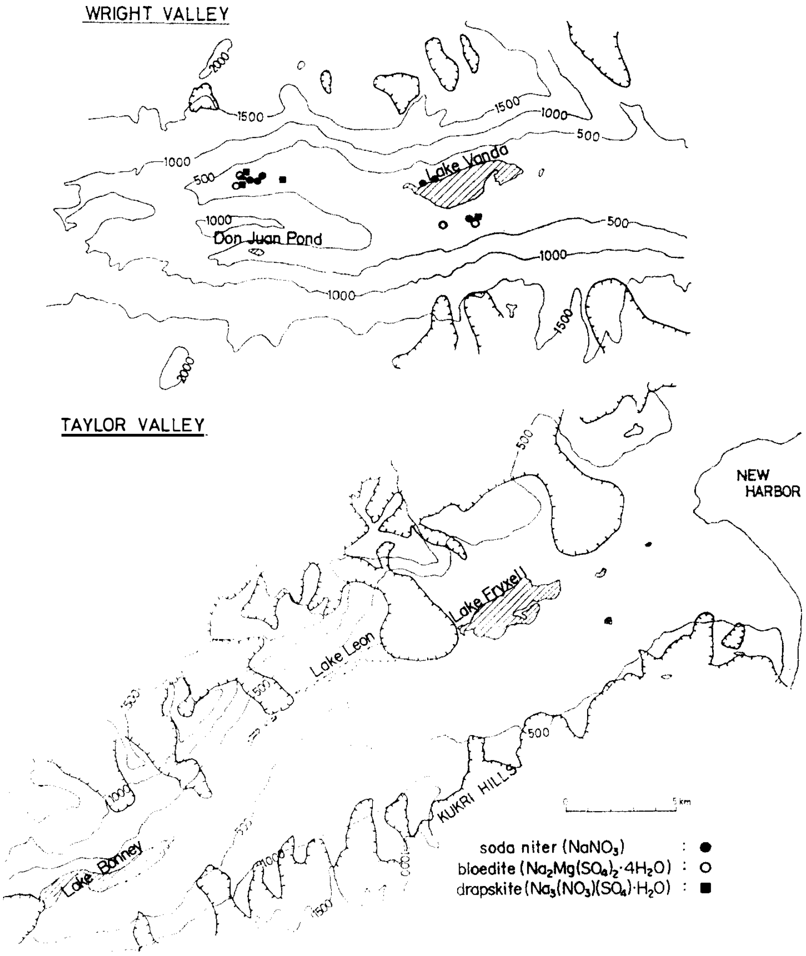

Fig. 4d. Soda niter, bloedite and darapskite.

amount of snowfall and abundant glacial melt water in summer, but the Wright Valley is always dry and melt water is not so abundant. It seems that variation of distribution of evaporite minerals mentioned may be due to the differences during complex process of deposition from sea water influenced by topographical and meteorological conditions. Marine origin is also indicated by isotopic data (*e.g.* NAKAI *et al.*, 1975).

THOMPSON and NELSON report that mirabilite or saturated solutions of the mineral would tend, under proper conditions, to react very slowly with calcium carbonate, with the formation of calcium sulfate and sodium carbonate. Mirabilite or thenardite in the eastern Taylor Valley might have reacted under certain conditions very slowly with calcium carbonate, and then sodium carbonate and calcium sulfate have been produced. Burkeite may be considered as an intermediate product of this reaction.

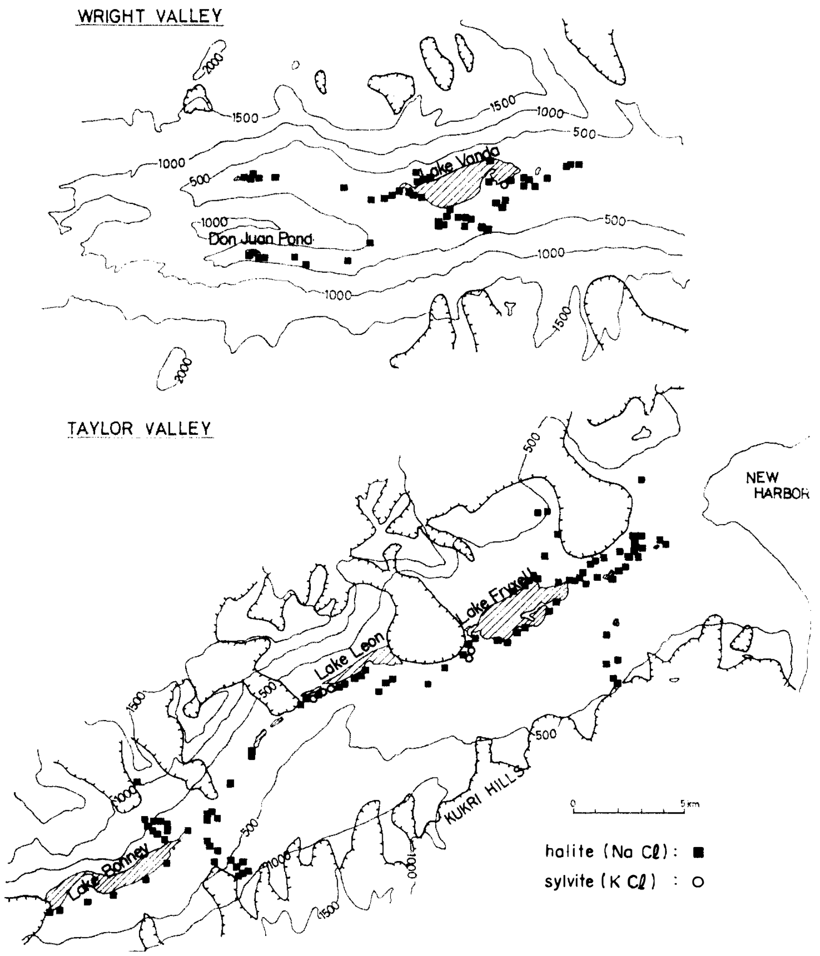

Fig. 4e. Halite and sylvite.

Judging from the nature of some minerals in cores (like fluorite, chabazite, and laumontite that are often of hydrothermal origin), a small amount of salts in core samples is formed from hydrothermal solution.

Acknowledgments

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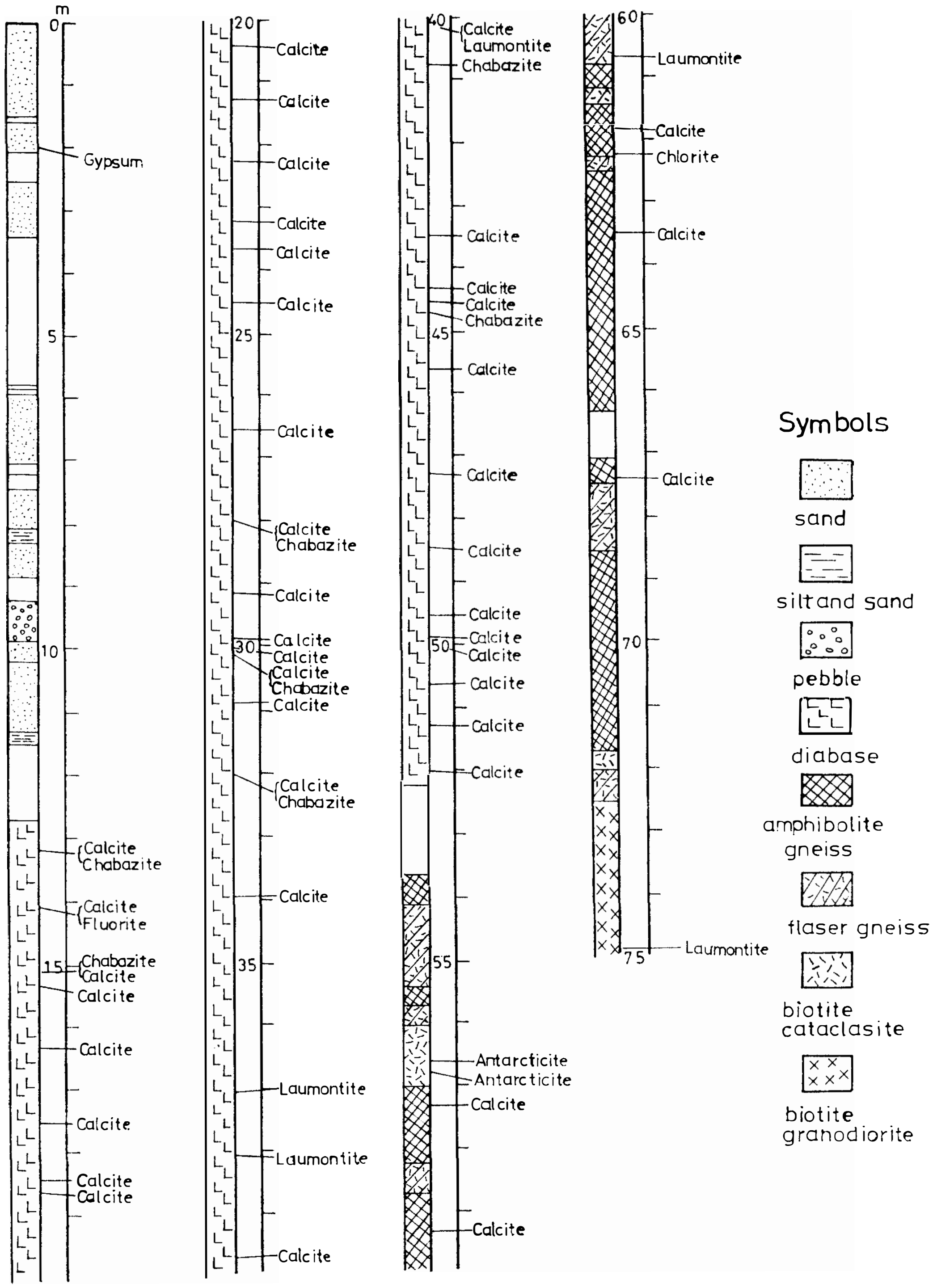

Fig. 5. Secondary minerals in cores from hole DVDP 13 (Don Juan Pond).

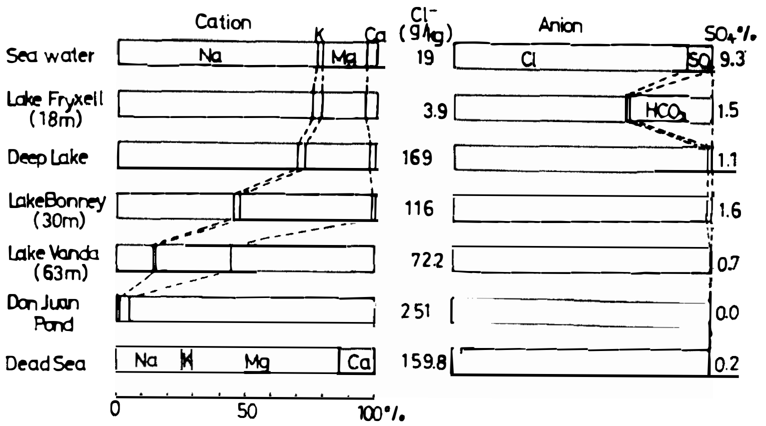

Fig. 6. Chemical compostion of saline waters (after YAMAGATA *et al., 1967).*

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