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A COMPARISON OF RED SOILS FROM SOUTH AUSTRALIA AND JAPAN

PRIMERJAVA RDEČIH PRSTI IZ AVSTRALIJE IN JAPONSKE

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Izvleček: UDK 631.44(94+520)

Kazuko Urushibara-Yoshino: Primerjava rdečih prsti iz Avstralije in Japonske

Avtorica je vzorčevala prsti s karbonatnih peskov in terciarnih apnencev v južni Avstraliji, kjer je tipično mediteransko podnebje. S starostjo peščin se manjšajo kalcitna zrna v prsti, s starostjo pa upada tudi aktivnost železa. Po drugi strani pa s starostjo narašča kristalizacija železa. Aktivnost železa postane izredno majhna v istem starostnem razredu, a v monsunskem podnebju otočja Nansei (Japonska). Tudi tekstura B horizonta se spremeni, namesto grobega peska je visoka vsebnost gline. Drugi namen prispevka je tudi primerjava hitrosti razvoja lastnosti prsti na Kitajskem.

Ključne besede: krasoslovje, pedologija, rdeča prst, Avstralija, Japonska.

Abstract UDC 631.44(94+520)

Kazuko Urushibara-Yoshino: A comparison of red soils from South Australia and Japan

The soils formed from calcareous sands and from the Tertiary limestone in South Australia were sampled. The climate in the area is a typical Mediterranean. The calcite grain in the soils decreases with the age of the sand dunes. The iron activity in the soils decreases with age. On the other hand, the iron crystallinity increases with age. The iron activity became extremely small during the same age under Monsoonal climate of Nansei Islands (Japan). The texture of B horizons also change from rich coarse sand to high clay contents. Second purpose is to compare the development speed of soil properties in the Karst areas in China also.

Key words: karstology, pedology, red soil, Australia, Japan.

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INTRODUCTION

In areas of calcareous rocks, the rate of soil development is extremely slow, when we compared it in areas with non-calcareous rocks. The dating of soils is very difficult in karst areas. In this paper the dating of mother materials is used to make a relative time scale for the soils. Of course, it must have some time lag in forming soils from the mother materials.

The first purpose of the present paper is to find better indices of soil properties that change with time. The study areas are, therefore, very limited, because the mother materials have to be dated. As examples, the Nansei Islands of Japan and the south-east coastal region of South Australia have been chosen as study areas.

The second purpose of the study is to compare the development speed of soil properties under the influence of different climates - the Monsoon climate areas of Japan as an example of rather wet climate areas, and the Mediterranean climate area of South Australia as rather dry climate areas.

The results of previous studies have made clear the following. The younger processes of the soil developments (A/C) are similar, and have been named Rendzina in areas of different climate. Rich humus can remain for a longer time, because of the combination with rich calcium ion. After the soils were matured as (A/B/C) profile, the clay contents became higher. The heavy soil was called as Terra Rossa in the Mediterranean climate. The rich bases have been kept for a longer time in soil profiles in the dry and summer season.

In the Nansei Islands of Japan, local people called the clayish soils on the uplifted coral reefs Shimajiri Maji. However, the properties of mature soils in limestone areas in Japan may not accurately correspond to Terra Fusca and Terra Rossa in the Mediterranean climate areas. Kato (1989) describes the progressive series from Rendzina-like soil, Terra Fusca-like soil, Terra Rossa-like soil (dark red soil) to ferrallitic red soil in East and South-East Asia. The reaching of bases and de-silicification and aluminisation also occur predominantly in the older soils in the karst areas in China (Nanjing Institute of Soil Sciences, Academia Sinica, 1978).

The South-East of South Australia

The study area chosen is from Naracoorte to Robe (about 100km) in the south-east of South Australia, in where Schwebel (1983, 1984) had done the sequence dating of calcarenite dunes using ^{14}C dating, Uranium Series, ^{18}O and Palaeomagnetism. The study area is shown in Fig. 1. The climate of this area is Cs by Köppen's classification. The annual precipitation is 580 mm, and the annual mean air temperature 8,1°C. Original vegetation with *Eucalyptus* and *Acacia* remain on the ridges of the dunes, but the other flat lands are used for pastures. A soil map has made by Blackburn (1983). In the coastal sand dune

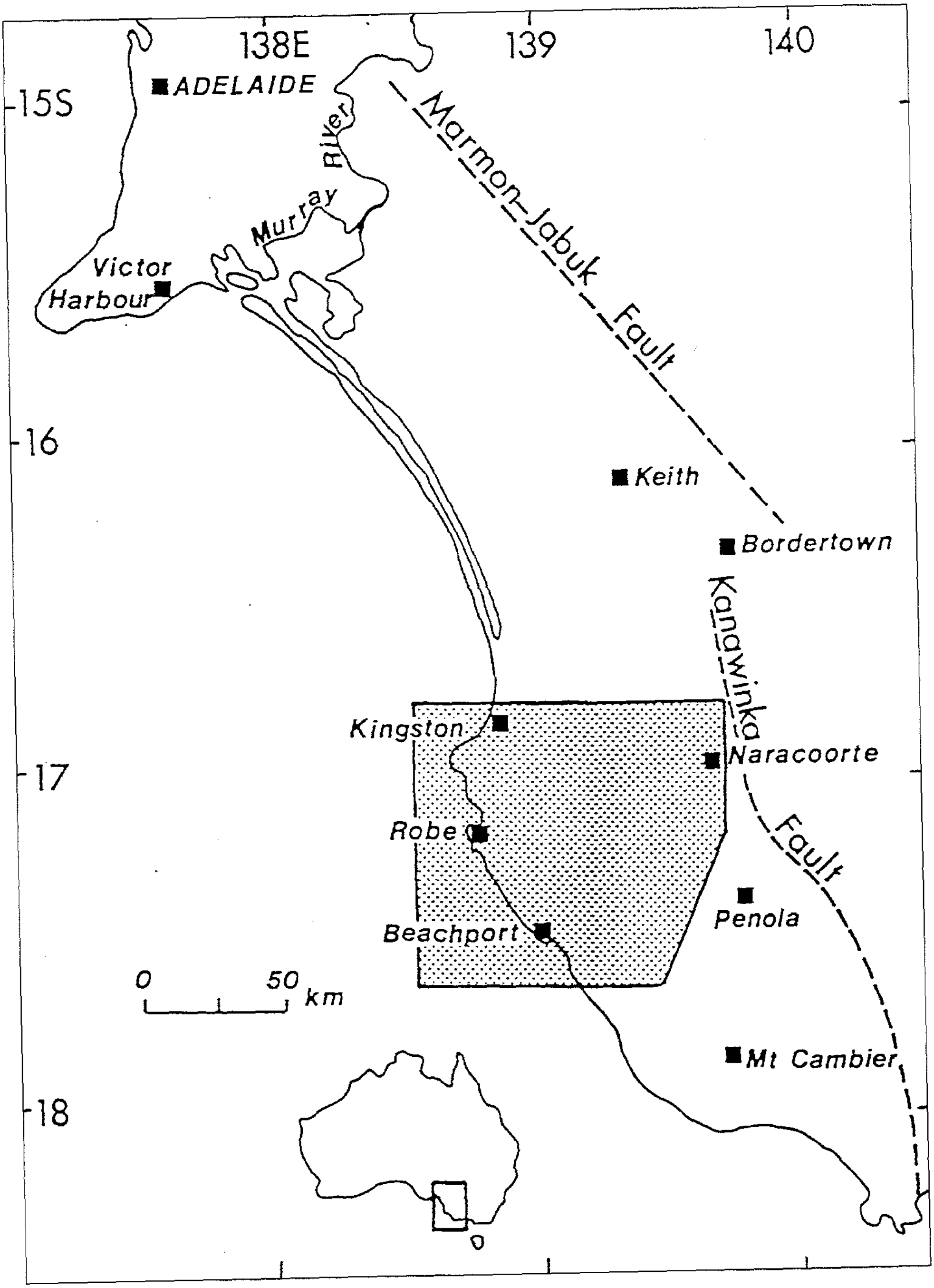
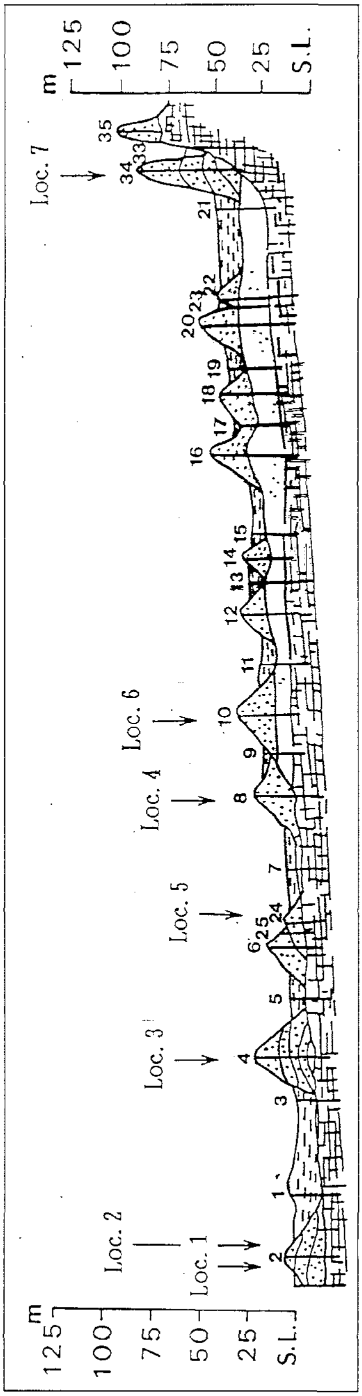


Fig. 1: Study areas of south-east South Australia.



areas, ^{14}C dating has done by Ohmori et al. (1987). The results are from 1,500 yr. B.P. to 5,000 yr. B.P.. Schwebel (1983, 1984) dated sand dunes as follows. The soil sample places and dating points are shown in Fig. 2.

Dating as
BMR 2 RI (4,300±100 yr. B.P.)
:Soil sample Locality 1
BMR 2, RII, RIII (83,000~93,000 yr. B.P.)
:Soil sample Locality 2
BMR 4 (125,000 yr. B.P.)
:Soil sample Locality 3
BMR 8 (248,000 yr. B.P.)
:Soil sample Locality 4
BMR 24, ED (309,000 yr. B.P.)
:Soil sample Locality 5
BMR 10, WA (347,000 yr. B.P.)
:Soil sample Locality 6
BMR 34, WNIV (690,000 yr. B.P.)
:Soil sample Locality 7
Miocene, Tertiary limestone
:Soil sample Locality 8

The calcite contents of A_1 horizon in Locality 1 is higher than the quartz. But in the B horizon at Locality 2, where the dune is dated as 83,000~93,000 yr. B.P., the calcite contents is only 1%. Especially, calcite is non-existent in the B_2 horizon at Locality 7 (690,000 yr. B.P.) and Locality 8 in the area of Tertiary limestone.

The texture of B horizons also changes from rich coarse sand to high clay contents with increasing age of the sand dunes. The iron in a typical horizon in each soil profile has been analysed by three methods (Nagatsuka 1975), as follows:

Fig. 2: Profile of sand dunes by Schwebel, 1983 and the Locality numbers of soil samples.

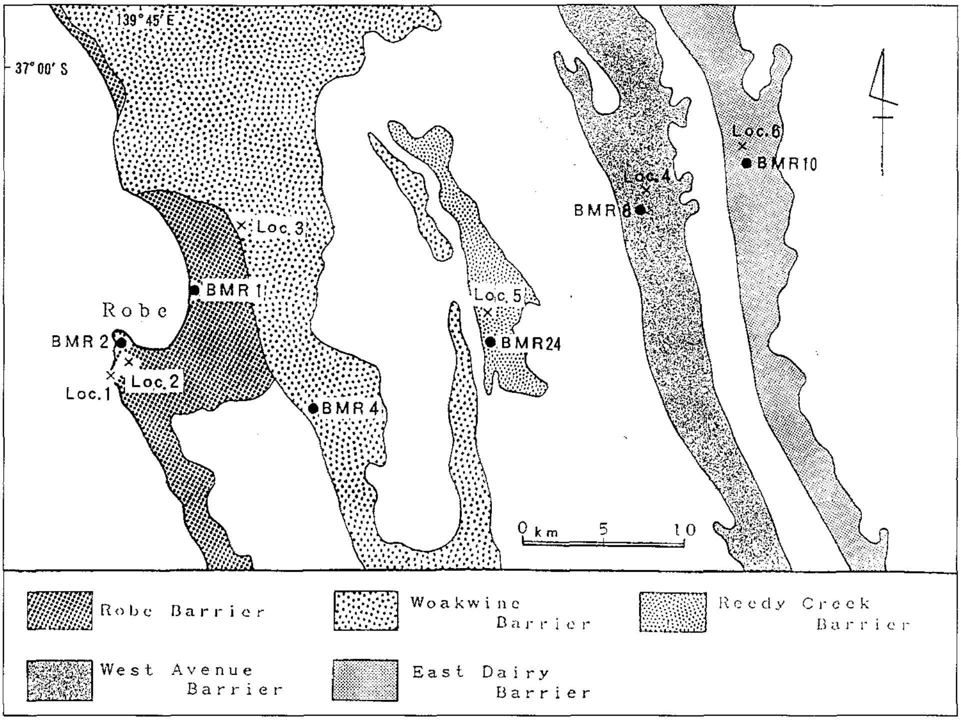


Fig. 2a: Map of sand dunes by Schwebel, 1983 and the Locality numbers of soil samples.

Fe_o: Tamm solution (Tamm 1934), was used for extraction. This solution can extract free irons of absorbed states, free iron combined with organic matter, amorphous ferric hydroxide and almost all of lepidocrocite, magnetite and some goethite.

Fe_d: Free iron oxide extracted by the dithionite-citrate-bicarbonate solution is expressed as Fe_d (Mehra and Jackson 1960).

Fe: Total iron, which is expressed as Fe_t, is extracted in a specially designed vessel made of Teflon by hydrochloric acid, nitric acid and hydrogen fluoride.

Fe_o/Fe_d is expressed as activity ratio of free iron oxide. $(Fe_d - Fe_o)/Fe_t$ shows the crystallinity ratio of iron oxides.

The iron activity (Feo/Fed) shows a high value in younger dunes. On the other hand, iron activity decreases with the age of sand dunes. The iron crystallinity, $(Fe_d - Fd_o)/Fe_t$, ranges from 0.3 to 0.55 according to age. However, the value from 125,000 yr. B.P. shows an anomalous positive deviation from the general trend curve.

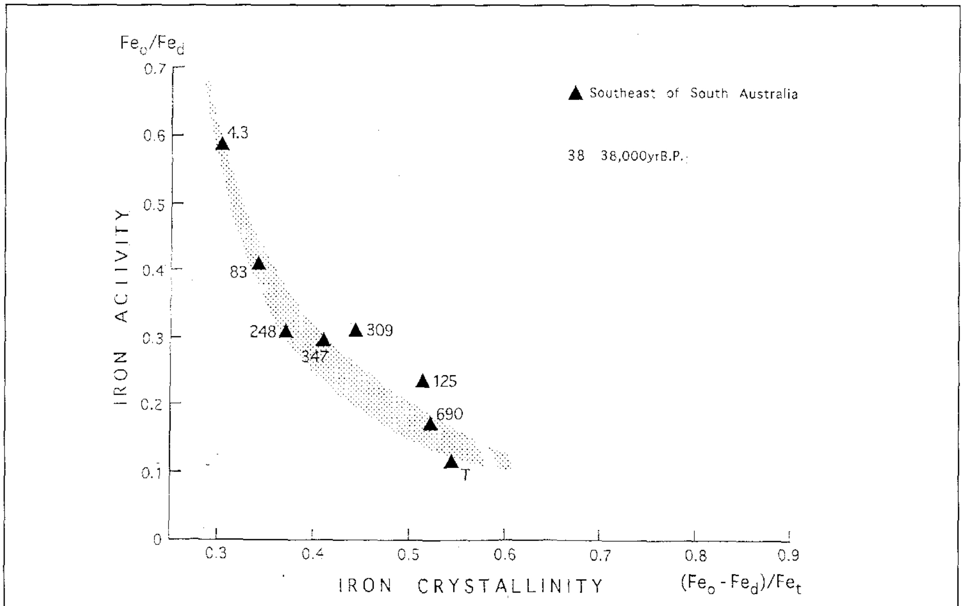


Fig. 3: The iron activities and iron crystallinities of typical horizons in south-east South Australia.

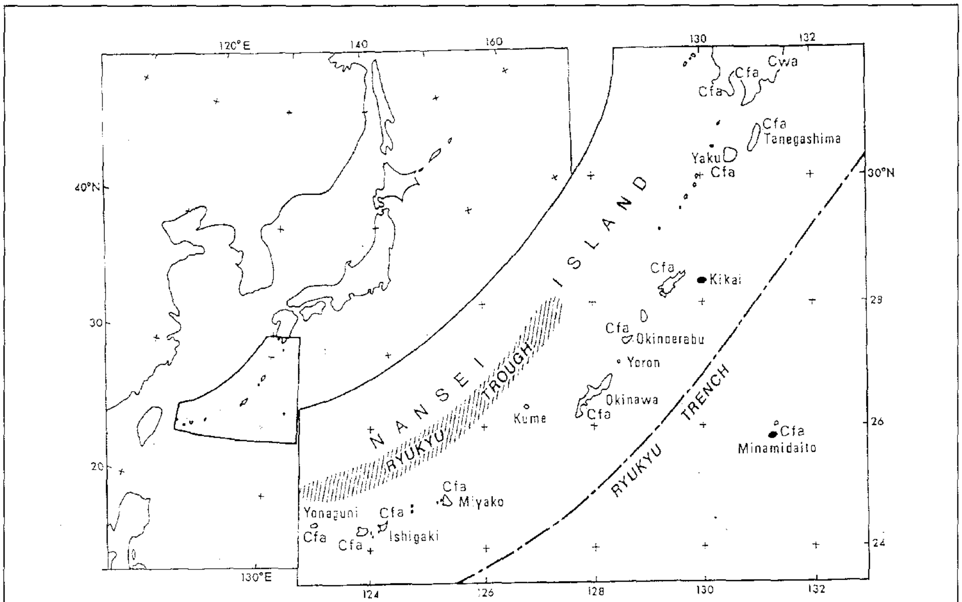


Fig. 4: The distribution of prevailing Köppen's climate in Nansei Islands in Japan and the location of the study islands.

The relationship between iron activity and iron crystallinity with age is shown in Fig. 3. An anomalous value for 125,000 yr. B.P., as mentioned above, is clearly seen in this figure. It is estimated that calcite increases and quartz amounts decrease around 125,000 yr. B.P. The soils iron activity decreases and iron crystallinity increases under the local conditions, especially under the wetter conditions of the soils rather than the other calcareous dunes.

Nansei Islands in Japan

In the Nansei Islands, the highest uplift rate is 1.8-2.0 mm/year, which is estimated by the sequence of uplifted coral terraces on Kikai Island. The soils have been taken on each terrace, of which corals were dated as 125,000 yr. B.P., 90,000~80,000 yr. B.P., 65,000~55,000 yr. B.P., and 38,000 yr. B.P. (Konishi et al. 1974). Then the soils were analysed. Furthermore, soils on terraces older than 125,000 yr. B.P. had been taken from Minamidaito Island. The oldest part of this island is estimated as at least one million years old. Both islands are shown in Fig. 4.

These areas belong to the subtropical Monsoon climate. In Köppen's climate classification, Cfa appears dominantly (Urushibara 1980). The Nansei Islands are relatively humid in contrast to the surrounding areas, because the Pacific Polar Frontal Zone is located over these islands in winter. The annual temperature is 22.9°C and the annual precipitation is 1673 mm in Minamidaito island.

The soil profiles on the old terraces are thicker than on the younger terraces. The results of iron activities and iron crystallinities of soils were analysed and considered with the age of terraces (Urushibara-Yoshino 1989, 1992). The crystallinity of iron in B_2 horizons increases with decreasing iron activity in accordance with the age of terraces as shown in Fig. 5. The free iron oxides in the soils decreased rapidly with the age of the terraces. These conditions were thought to result from the Monsoon, wet and hot climate.

Comparison of Red Soils

Iron crystalline properties of red soils formed from calcareous materials were compared in the south-east of South Australia and in the Nansei Islands of Japan. The iron activities of soils are very high in south-east South Australia, and the iron crystallinities are smaller than that of the Nansei Islands. The trend curve of both indices is more steep in south-east South Australia than in the Nansei Islands.

The soils, whose mother materials were dated as around 80,000 yr. B.P., were compared in both areas. The iron activities of soils in south-east South Australia are about 10 times higher than that of the Nansei Island's soils. The crystallinity of iron in soils in the Nansei Islands, of same age, is twice that of

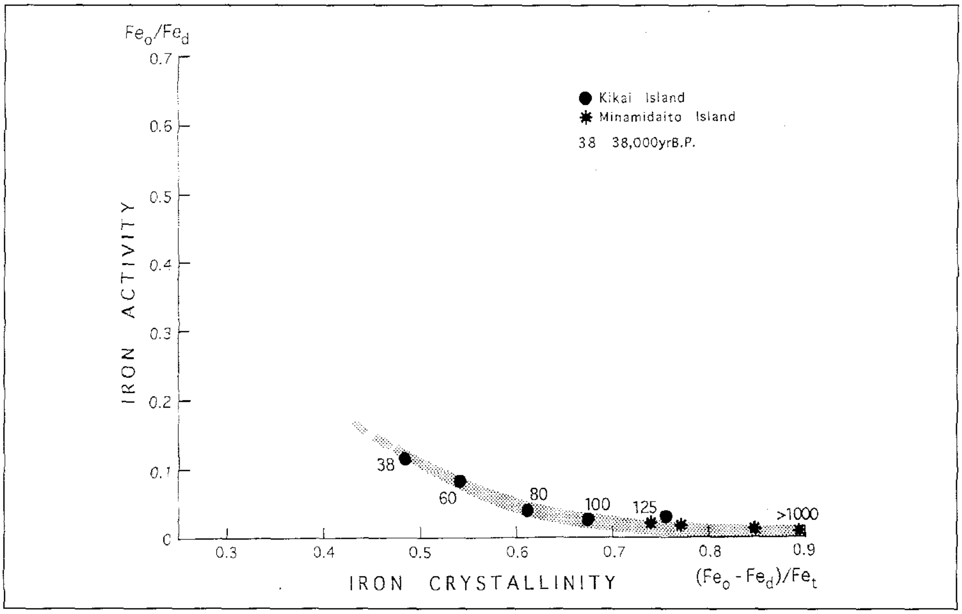


Fig. 5: The iron activities and the iron crystallinities in B_2 horizon in Nansei Islands.

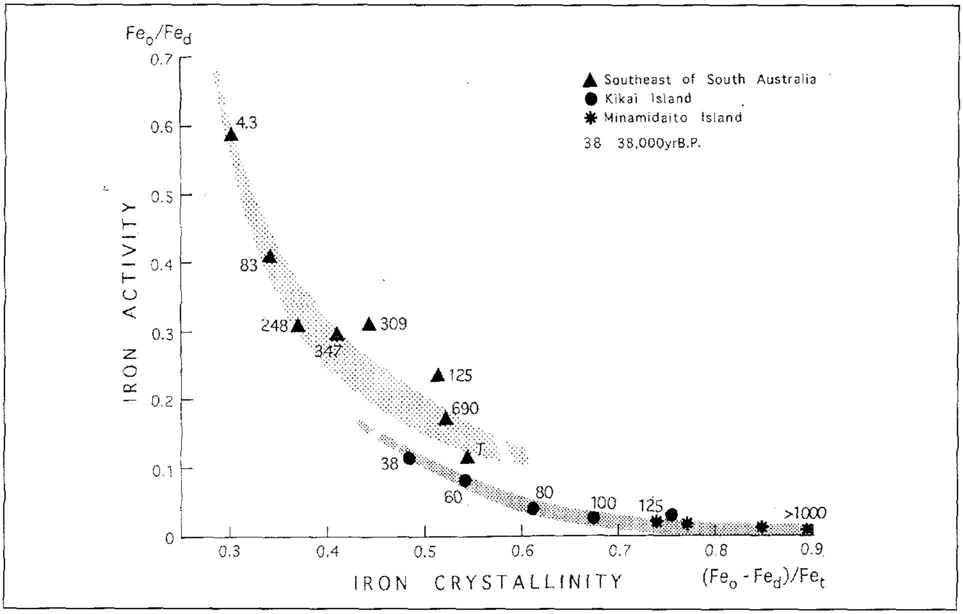


Fig. 5a: The iron activities and the iron crystallinities in B_2 horizon in South Australia.

the South Australian soils. The trends of both indices is same in the other ages also. From these results, it can be concluded that free iron can keep for a longer time in the Mediterranean climate than in the Monsoon climate. On the contrary, the iron crystallinity of soils increases more rapidly under the Monsoon climate than the Mediterranean climate. It should be stressed that the speed of the soil formation process is different under different climate conditions, even though the shape of the trend curves is almost similar.

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PRIMERJAVA RDEČIH PRSTI IZ AVSTRALIJE IN JAPONSKE

Povzetek

Avtorica je vzorčevala prsti s karbonatnih peskov na koralnih grebenih japonskega otočja Nansei (domače ime zanje je Shimajiri Maji), dvignjenih nad morsko gladino, in s terciarnih apnencev v jugovzhodni Avstraliji, kjer je tipično mediteransko podnebje. S starostjo peščin se manjšajo kalcitna zrna v prsti, kvarcitna zrna so vedno bolj zaobljena, s starostjo pa upada tudi aktivnost železa. Po drugi strani pa s starostjo narašča kristalizacija železa. Prsti s karbonatnih sipin so stare med 4.300 leti B.P. in 690.000 leti B.P. V monsunskem podnebju otočja Nansei, postane aktivnost železa izredno majhna v istem starostnem razredu. Tudi tekstura B horizonta se spremeni, namesto grobega peska je visoka vsebnost gline. S starostjo se v vlažni in vroči klimi delež prostega železa zelo hitro manjša. Bogatenje z bazami, desilifikacija in aluminizacija so procesi, ki prevladujejo tudi v starejših prsteh na kitajskem krasu.