REGIONAL VARIATION OF MAGNETIC SUSCEPTIBILITY OF THE LACHLAN FOLD BELT GRANITOIDS, SOUTHEASTERN AUSTRALIA

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Abstract Magnetic susceptibility was measured on powdered samples of granitoids from the Lachlan Fold Belt in southeastern Australia where typical I- and S-type granitoids are widely distributed. All of the S-type granitoids studied give magnetite free magnetic susceptibility values with the exception of those of the Kosciusko Basement Terrane. Thus, the S-type granitoids belong to the ilmenite-series except for a few plutons. On the other hand, many I-type granitoids studied give magnetite bearing magnetic susceptibility values with the exception of those in some basement terranes which are magnetite free. Namely, many I-type granitoids belong to the magnetite-series with a few exceptions. The I-type granitoids which belong to the ilmenite-series have slightly higher magnetic susceptibility than the S-type granitoids. The I-type granitoids in the S-type dominant basement terrane have slightly lower magnetic susceptibility than those of the I-type dominant basement terrane. The A-type granitoids studied belong to the ilmenite-series, but their magnetic susceptibility values are usually higher than that of majority of the S-type granitoids. Thus, the magnetic susceptibility data reflect the chemical differences between A-, S- and I-type granitoids.

Many I-type granitoids of the Bega, Kosciusko and Grampians-Stavelly Basement Terranes give magnetite bearing values, but the magnetic susceptibilities of the I-type granitoids of other basement terranes such as the Melbourne, Howqua and Wagga Basement Terranes give magnetite free values. The magnetic susceptibility values of the Bega Basement Terrane are the highest but the values of the magnetite bearing granitoids in this basement terrane decrease towards the Kosciusko Basement Terrane. In the S-type granitoids, those of the Kosciusko Basement Terrane have the highest magnetic susceptibility and those of the Wagga Basement Terrane have the lowest. In general, the magnetic susceptibility changes abruptly at the boundaries between one terrane and another.

Introduction

CHAPPELL & WHITE (1974) recognized that the majority of granitoids in southeastern Australia are of two types which may be distinguished by chemical, mineralogical and field criteria. These granitoids, the I- and

S-types, were interpreted as being derived by partial melting of two different types of source material, igneous (I) and sedimentary (S). On the other hand, the magnetite- and ilmenite-series granitoids of ISHIHARA (1977) are characterized by the presence or absence of magnetite, though ilmenite may be present in both series. They have been distinguished by differences in magnetic susceptibility (KANAYA & ISHIHARA, 1973; ISHIHARA, 1979). Both the magnetite- and ilmenite-series scheme and the I- and S-type classification are significant in understanding the problems of the

Received November 20 1987. Accepted June 9, 1988.

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Fig. 1. Relation between magnetic susceptibility and I-, S- and A-type granitoids. The boundary between the magnetite-series and the ilmenite-series is tentatively set at 100×10^{-6} emu/g (ISHIHARA, 1977, 1981).

origin of granitoids (TAKAHASHI *et al.*, 1980). Magnetic susceptibility has been measured on powdered samples of granitoids from the Lachlan Fold Belt in southeastern Australia. This paper is concerned with regional variations in magnetic susceptibility in southeastern Australia and discusses the relationship between the I- and S-type granitoids and the magnetite- and ilmenite-series granitoids. The differences of magnetic susceptibility between the basement terrane in the southeastern Australia are also examined.

Magnetic susceptibility

Magnetic susceptibility was measured on powdered samples with a Bison magnetometer Model 3101 and is expressed in χ (emu/g) (KANAYA & ISHIHARA, 1973). Rock samples are crushed by a jaw crusher, and finally, about 60 mesh size of powder were prepared by agate grinder. This method can be considered that there is no effect of the iron contamination (ISHIHARA, 1979). The amount of magnetite is measured using its magnetic susceptibility, because magnetite is only strong magnetic mineral in granitoids (KANAYA & ISHIHARA, 1973; ISHIHARA, 1979). The magnetic susceptibility has a positive correlation with the content of magnetite and its measurement is most convenient way to know regional distribution of magnetite in granitoids (ISHIHARA, 1979).

The boundary between the magnetite-series and the ilmenite-series according to ISHIHARA (1977, 1981) is tentatively drawn at 100×10^{-6} emu/g. Under ore-microscopic observation, magnetite is commonly seen in Australian granitoids having χ higher than 100×10^{-6} emu/g. In the Lachlan Fold Belt, the magnetite-free granitoids under ore-microscope observation exhibit relatively lower χ values than magnetite-series granitoids ($> 100 \times 10^{-6}$ emu/g) (Fig. 1). In this paper, we use this value (100×10^{-6} emu/g) as a boundary between magnetite-series and ilmenite-series granitoids. Magnetic susceptibility values in this paper are average value of three rock samples at one locality. Magnetic susceptibility of each pluton in the basement terrane is summarized in Table 1.

General geology of the Lachlan Fold Belt

The Lachlan Fold Belt forms the south-eastern part of Australia (Fig. 2). It comprises rocks ranging in age from Cambrian to Devonian. Granitoids have intrusive ages which range from 370 to 420 Ma (WHITE & CHAPPELL, 1983). About 400 plutons occur in the eastern part of the Lachlan Fold Belt. Felsic volcanic activity also occurs in Silurian and Devonian times (WYBORN *et al.*, 1981). Batholiths are elongate in a north-south direction, parallel to the trend of the folds in

Table 1. Average of magnetic susceptibility value for each pluton of the basement terrane in the Lachlan Fold Belt.

Average of magnetic susceptibility for the plutons in the Basement Terrane

Magnetic susceptibility($\times 10^{-6}$ emu/g)

Range Number of Average analysis

Bega Basement Terrane

I-type granitoids

486-578	4	532
160-246	4	211
97-268	5	165
23-70	4	46
340-402	3	361
148-610	4	350
155-195	4	175
486-578	5	520
20-50	4	33
9-16	4	13
160-246	5	211
81-98	4	97
123-307	5	218
22-97	4	63
350-743	7	547
15-21	4	18
102-108	4	105
121-821	4	545
1009-1648	3	1241
9-63	4	38
322-554	4	464
129-308	3	204
8-46	5	27

A-type granitoids

18-82 3 50

31-76 4 54

Inclusion in I-type granitoids

22-41	5	33
22-57	5	37
227-998	5	494
223-607	3	436
20-151	4	89
110-229	3	157
24-28	4	26
25-68	4	44

Average of magnetic susceptibility for the plutons in the Basement Terrane

Magnetic susceptibility($\times 10^{-6}$ emu/g)

Range Number of Average analysis

Stawell Basement Terrane

I-type granitoids

14-201	7	70
19-37	6	28
138-158	4	149
125-140	4	132
10-15	4	13
15-21	4	17
4-8	3	7
12-14	4	13

Grampians Stavelly Basement Terrane

I-type granitoids

469-686	3	611
403-410	4	405
403-523	2	463
430-478	2	454

Bassian Basement Terrane

I-type granitoids

110-135	4	120
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S-type granitoids

9-22 6 15

Taswegia Basement Terrane

I-type granitoids

389-394	3	391
354-370	3	362
127-140	2	134
23-31	3	27
18-31	2	25

S-type granitoids

4-8 4 6

12-16 4 14

Average of magnetic susceptibility for the plutons in the Basement Terrane

Magnetic susceptibility($\times 10^{-6}$ emu/g)

Range Number of Average analysis

Kosciusko Basement Terrane

Berridale Batholith

I-type granitoids

311-174	4	242
9-20	3	15
331-410	4	358
368-568	3	507

S-type granitoids

18-51	3	35
12-14	4	13
3-20	4	12
7-18	3	13
2-76	4	35
13-40	4	23
3-13	4	8
5-10	4	7

Kosciusko Batholith

I-type granitoids

326-386	4	356
590-604	4	604
313-378	4	346
150-171	4	159
254-367	4	311
300-320	4	306
10-15	4	13

S-type granitoids

23-28	4	24
12-25	4	18
16-35	4	23
13-17	3	15
12-13	2	13
9-17	3	17

Inclusions in S-type granitoids

25-47	4	38
24-38	4	31

Average of magnetic susceptibility for the plutons in the Basement Terrane

Magnetic susceptibility($\times 10^{-6}$ emu/g)

Range Number of Average analysis

Howqua Basement Terrane

I-type granitoids

12-23	4	19
34-42	4	38
34-116	4	57
5-12	4	9
30-47	5	38

S-type granitoids

6-17 4 11

Melbourne Basement Terrane

I-type granitoids

3-27	14	9
9-46	3	27
13-18	3	15
9-44	8	16
7-22	4	18
6-11	4	9
5-13	4	9
4-18	4	11
9-16	4	13
4-8	4	6

S-type granitoids

6-12	5	9
11-23	6	17
5-8	8	10
6-8	4	7
33-38	4	34
6-9	4	8
4-7	4	6
4-7	4	6
10-15	4	13

S-type volcanic rocks

39-117	7	58
5-12	3	10
23-46	6	39
24-34	6	30

Average of magnetic susceptibility for the plutons in the Basement Terrane

Magnetic susceptibility($\times 10^{-6}$ emu/g)

Range Number of Average analysis

Wagga Basement Terrane

I-type granitoids

5-15	4	11
6-47	4	27
8-11	3	10
6-80	4	37
307-414	4	377
17-25	4	21
103-280	4	195
336-1983	2	1159
126-225	3	159
9-15	4	12
31-34	3	32
15-19	4	17
12-18	4	15

S-type granitoids

5-10	3	8
9-12	3	12
10-19	4	15
9-25	4	18
6-9	4	8
17-23	4	20

A-type granitoids

6-13 5 9

12-189 4 103

the country rocks. Both the I- and S-type granitoids are extensively developed (Fig. 2). Their distribution is apparently controlled by deep-seated geological features. A line separates dominantly S-type granitoids to the

west from exclusively I-types in the east. This line is called the I-S line (WHITE *et al.*, 1976), which is thought to represent the eastern limit of thick crystalline basement. The S-types are distributed in some basement

Fig. 2. Exposure of granitoids and location of those examined in the Lachlan Fold Belt.

Broken lines show the boundary of the basement terrane (CHAPPELL *et al.*, 1988). A I-S line separates dominantly S-type granitoids to the west from exclusively I-types in the east (WHITE *et al.*, 1977). The I-S line trending N-S ranging through the Berridale Batholith, is the boundary of the Bega and Kosciusko Basement Terranes.

Symbols indicate a different range of magnetic susceptibility of one pluton or one given area.

I-type granitoids: 1. χ less than 50×10^{-6} emu/g, 2. 50–100, 3. 100–360, 4. χ more than 360,
 S-type granitoids: 5. χ less than 50, 6. 50–100, 7. 100–360,
 A-type granitoids: 8. χ less than 50, 9. 50–100, 10. 100–360,
 Inclusions: 11. χ more than 100, 12. χ less than 100.

Fig. 3. Magnetic susceptibility and the distribution of granitic plutons in part of the Bega Batholith (Geology after CHAPPELL & WHITE, 1976).

I-type granitoids : 1. 100— 360×10^{-6} emu/g, 2. χ more than 360, 3. χ less than 50, 4. 50—100, A-type granitoids : 5. χ less than 50, 6. 50—100.

terrane. For example, the Kosciusko Belt (or “Basement Terrane”), which is dominated by the S-types, is separated from the Bega Basement Terrane by the I-S line (WHITE *et al.*, 1977) (Fig. 2).

Granitoids in the Lachlan Fold Belt can be divided into many basement terranes (CHAPPELL *et al.*, 1988). Each basement terrane consists of numerous separate batholiths which made up of many lithologically mappable units appearing as separate plutons.

Opaque minerals of I-type normally include magnetite with or without ilmenite and ilmenite without magnetite is also present in some basement terrane (WHITE & CHAPPELL, 1983 ; WHALEN & CHAPPELL, 1988). In S-type granitoids, ilmenite is the normal accessory opaque oxide. A-type granitoids consist of felsic granitoids, mostly with amount of ilmenite with or without magnetite.

Magnetic susceptibility of the granitoids in the Lachlan Fold Belt

The general distribution pattern of the

magnetite- and ilmenite-series granitoids in the Lachlan Fold Belt is given here together with some of their geological features.

As mentioned previously, the magnetite-series and ilmenite-series granitoids are divided by magnetic susceptibility of 100×10^{-6} emu/g (ISHIHARA, 1977, 1981). Rocks predominantly exhibit magnetic susceptibility higher than this value are termed “magnetite bearing granitoid” or “magnetite-series granitoid”. If rocks have lower magnetic susceptibility values than this value, they are termed “magnetite free granitoid” or “ilmenite-series granitoid”.

Bega Basement Terrane

The Bega Basement Terrane is located in the most eastern part of the Lachlan Fold Belt. It is dominantly composed of rocks of the Bega Batholith which ranges from tonalite through hornblende-biotite granodiorite to felsic biotite adamellite and aplite (CHAPPELL & WHITE, 1976). All of the granitoids are I-type (CHAPPELL & WHITE, 1976). Magnetite bearing rocks are predominant in the Bega Batholith and they are strongly magnetic,

Fig. 4. Magnetic susceptibility across the main part of the Lachlan Fold Belt.

1. magnetite-series : I-type granitoids, 2. ilmenite-series : I-type granitoids, 3. ilmenite-series : S-type granitoids, 4. ilmenite-series : S-type acidic welded tuff, 5. ilmenite-series : A-type granitoids, 6. Inclusions.

but there are scattered magnetite free varieties (Fig. 3). The Kameruka and Nimmitabel plutons consist of magnetite free granitoids (Fig. 3). The Kameruka granitoids have large K-feldspars and their texture is different from others in the Bega Batholith. The Nimmitabel pluton is composed of a felsic granite.

The Moruya Batholith consists of a string of ten elliptical plutons ranging in composition from biotite adamellite to granodiorite, tonalite, quartz diorite and gabbroic diorite (CHAPPELL & WHITE, 1976). Many these granitoids are I-type except for a few leuco granitoids. Magnetite-series granitoids are predominant.

The A-type granitoids associated with volcanic rocks at the eastern edge of the Bega Batholith are thought to have been derived from crustal materials that had previously produced I-type magma (COLLINS *et al.*, 1982). However, WORMALD & PRICE (1988) believe that A-type granitoids are products of crystal fractionation of the I-type magma. These granitoids have miarolitic cavities and granophyric intergrowths. They are late Devonian, postdating the Bega Batholith.

Most of these A-types give magnetic susceptibilities around 50×10^{-6} emu/g suggesting

magnetite free types, although they are somewhat higher than those of ilmenite-series granitoids (Fig. 4). Their low magnetic susceptibility may be due to fractionation of early formed magnetite. These magnetic susceptibility values are different from those of the Bega Batholiths.

Magnetic susceptibility decreases gradually from the Bega to the Kosciusko Batholiths. However, the boundary between the magnetite- and the ilmenite-series granitoids can be drawn at the I-S line (Fig. 4).

The Cooma Granodiorite has an outcrop area of only 30 km² on the boundary of the Bega and Kosciusko Basement Terranes. It is a medium to coarse grained rock, rich in biotite and with inclusions of meta-sedimentary origin. All Cooma granodiorites belong to S-type granitoids (CHAPPELL & WHITE, 1976). The Cooma Granodiorite is characterized by low values of magnetic susceptibility with a value below 10×10^{-6} emu/g. These values are the lowest in the Lachlan Fold Belt.

Kosciusko Basement Terrane

The Berridale Batholith consists of I-type granitoids in the east, and dominantly S-types in the west. The I-type granitoids of the

Fig. 5. Magnetic susceptibility in a part of the Berridale Batholith (Geology after CHAPPELL & WHITE, 1976).

1. χ less than 50×10^{-6} emu/g, 2. 50–100, 3. 100–360, 4. χ more than 360.

Berridale Batholith range from hornblende-biotite granodiorite to felsic granite (CHAPPELL & WHITE, 1976). The S-type granitoids range from cordierite biotite granodiorite to felsic, inclusion-poor granitoids (CHAPPELL & WHITE, 1976). Many of the S-type granitoids of the Berridale Batholith have values below 50×10^{-6} emu/g (Fig. 5). However, some slightly more magnetic samples are observed in the S-type granitoids found near Berridale (Fig. 5): some of the S-type granitoids may belong to the magnetite-series.

All of the I-type granitoids in the Berridale Batholith are characterized by high magnetic susceptibility. At the boundary between the Bega and Kosciusko Batholiths, the I-type granitoids of the Bega Batholith have slightly lower magnetic susceptibility than those of typical I-type granitoids (Fig. 4).

Fig. 6. Magnetic susceptibility in the Kosciusko Batholith (Geology after CHAPPELL & WHITE, 1976).

1. χ less than 50×10^{-6} emu/g, 2. 100–360, 3. χ more than 360.

On the other hand, the S-type granitoids of the Berridale Batholith have slightly higher magnetic susceptibilities than those of typical S-types.

The Kosciusko Batholith consists dominantly of S-type granitoids, with minor I-types particularly in the east (Fig. 6). The S-type granitoids range from biotite- and inclusion-rich granodiorites to moderately felsic biotite adamellites. Most of the I-type granitoids range in composition from tonalite to diorite. All of the S-type granitoids give values corresponding to magnetite-free rocks although they are somewhat higher than those of the Corryong Batholith. The I-type granitoids give either magnetite bearing or magnetite free values.

Wagga Basement Terrane

The Wagga Basement Terrane is unique in

Fig. 7. Magnetic susceptibility in the Corryong Batholith (Geology after CHAPPELL & WHITE, 1976).

1. χ less than 50×10^{-6} emu/g, 2. 100–360.

the Lachlan Fold Belt in that it contains the Wagga metamorphic belt, a regional metamorphic belt characterized by high temperature and low pressure metamorphism. The granitoids are dominantly S-types which include muscovite-biotite granitoids (Fig. 7). All of the S-type granitoids have values below 50×10^{-6} emu/g, particularly the muscovite-bearing Koetong suite granitoids have a magnetic susceptibility below 20×10^{-6} emu/g. The I-type granitoids are mostly felsic with relatively low values of magnetic susceptibilities.

Howqua Basement Terrane

The granitoids consist dominantly of I-types. Rocks of individual plutons range from biotite adamellite to granodiorite. The plutons are more or less elliptically distributed. The granitoids generally have magnetite free values with occasional exceptions. Values measured on these granitoids are around 30×10^{-6} emu/g. The values are slightly higher than those of the ilmenite-series gran-

itoids of other terranes.

Melbourne Basement Terrane

The granitoids of this terrane consist of both I-type and S-type, the former type being dominant. The I-type granitoids range from granodiorite to adamellite. The S-type of the Strathbogie Batholith are cordierite-biotite bearing rocks (Fig. 8). This batholith is associated with S-type acidic welded tuff. All of the I-type granitoids have relatively low magnetic susceptibilities, which increases gradually from the Melbourne Basement Terrane towards the Stawell Basement Terrane (Fig. 4). There is no abrupt change of magnetic susceptibility value between the Melbourne and the Stawell Basement Terranes.

The S-type granitoids give magnetic free values which are below 30×10^{-6} emu/g. The values are lower than those of the S-type granitoids of other terranes. However, the magnetic susceptibility of the S-type acidic welded tuff is slightly higher than that of the granitoids.

Stawell Basement Terrane

All granitoids are I-type. Many plutons have an elliptical shape, and most of the granitoids contain hornblende-bearing granodiorite to adamellite. Many granitoids give magnetite bearing values but there are a few magnetite free plutons (Fig. 8). These magnetite-free granitoids have a somewhat lower magnetic susceptibility than those of other basement terrane.

Grampians-Stavelly Basement Terrane

All of the granitoids in this terrane are I-type granitoids, occurring as small plutons, granodiorite to adamellite in composition. All are strongly magnetic with the magnetic susceptibility values of around 500×10^{-6} emu/g (Fig. 8).

Taswegia Basement Terrane

Granitoids are I-types and less amount of S-type granitoids. Those consists of hornblende-bearing adamellite and biotite adamellite, respectively. Many of the granitoids are associated with tin or tungsten mineralization. The granitoids of the Taswegia Basement Terrane give both magnetite-bearing and magnetite free values. The former are domi-

Fig. 8. Magnetic susceptibility in the Howqua, Melbourne, Stawell, Grampians-Stavely, and Bassian Basement Terranes (Geology after CHAPPELL *et al.*, 1988).

The S-type granitoids are shown as stipple areas, whereas I-type granitoids are shown as open areas.

1. χ less than 50×10^{-6} emu/g, 2. 50–100, 3. 100–360, 4. χ more than 360.

nant.

Bassian Basement Terrane

Both S- and I-type granitoids are found in this terrane. The S-type granitoids give magnetite free values but they have a slightly higher magnetic susceptibility than typical ilmenite series. The I-type granitoids give magnetite bearing values.

Inclusions

The magnetic susceptibility of many inclusions was measured. These inclusions were collected from granitoids of the Melbourne, the Kosciusko and the Bega Basement Terranes. Inclusions from the Melbourne Basement Terrane are all ilmenite series I-type granitoids; these being mainly composed of fine-grained plagioclase, amphibole and quartz with subordinate amounts of K-feldspar and

biotite. Ilmenite is the only Fe–Ti oxide accessory mineral in these inclusions and the measured magnetic susceptibility values confirm their magnetite free nature (Fig. 2). However, the magnetic susceptibility values of inclusions from the Melbourne Terrane are slightly higher than those for the host granitoids and this is probably due to the higher amounts of mafic minerals in the inclusions relative to the host granitoids.

In the Kosciusko Basement Terrane, inclusions from the S-type granitoids can be divided into different types such as microgranular inclusions composed of fine-grained plagioclase, biotite and quartz with accessory ilmenite and cordierite, and gneissic inclusions consisting of biotite, muscovite, plagioclase, cordierite, sillimanite and K-feldspar. All of

the inclusions from S-type granitoids of the Kosciusko Basement Terrane give magnetic susceptibility values of the ilmenite series, which is consistent with their low $\text{Fe}^{3+}/(\text{Fe}^{2+} + \text{Fe}^{3+})$ values of whole rocks and also with the fact that ilmenite is the only Fe-Ti oxide accessory mineral.

Inclusions from the I-type granitoids of the Bega Terrane are composed of fine-grained plagioclase, hornblende and quartz with minor amounts of K-feldspar and biotite. They contain both magnetite and ilmenite as accessory minerals. Magnetic susceptibility values of the host granitoids of the Bega Terrane show magnetite series, but magnetic susceptibility values of the inclusions do not correspond to their host rocks: some inclusions give magnetite series values and others show values of the ilmenite series.

Relation between I- and S-type granitoids and magnetite- and ilmenite-series granitoids

All of the S-type granitoids studied give magnetic-free values although a few in the east part of the Kosciusko Basement Terrane are magnetite bearing values. Thus, the S-type granitoids belong to the ilmenite-series except for a few plutons. It is widely accepted that the S-type granitoids were derived from sedimentary sources (CHAPPELL & WHITE, 1974). All of the S-type granitoids studied give magnetite free values support the partial melt model of sedimentary sources (CHAPPELL & WHITE, 1974). The S-type granitoids have relatively low magnetic susceptibility and the low oxidation state, which are probably resulted from the reduction by carbon in source.

On the other hand, many I-type granitoids studied give magnetite bearing magnetic susceptibility values, with the exception of which the I-types in some basement terrane such as Melbourne Basement Terrane have magnetite free magnetic susceptibility values. Namely, many I-type granitoids belong to the magnetite-series although some I-type granitoids are ilmenite-series granitoids. Relative to the S-types, most of the I-types have high magnetic susceptibility values suggesting rela-

tively high oxidation state. Many I-type granitoids studied which give magnetite-bearing values support that the I-type granitoids have an origin from partial melting of primitive deep crust produced by the partial melting of mafic material (CHAPPELL & WHITE, 1974).

The A-type granitoids studied have relatively low magnetic susceptibility corresponding to magnetite free values. Thus, the A-type granitoids belong to the ilmenite series, but their magnetic susceptibility values are slightly higher than that of the majority of magnetite free I-type granitoids. The A-type granitoids studied consist of felsic granitoids with a little magnetite. The A-type granitoids are thought to have been derived from crustal material that had previously produced I-type magmas (WHITE & CHAPPELL, 1983). If early crystallized magnetite was removed from the magma, the residual magma have only a little magnetite. This process is considered to lead to relatively low magnetic susceptibility of the A-type granitoids. Thus, the low magnetic susceptibility values of the A-type granitoids can be interpreted by the fractionation of early formed magnetite.

Many I-type granitoids of the Melbourne, Howqua and Wagga Terranes give magnetite free values, but the magnetic susceptibility of the I-type granitoids of other terranes give magnetite bearing values. I-type granitoids in the S-type dominant terrane such as the Kosciusko Batholith also have magnetite bearing values, although these values are slightly lower than those of I-type dominant batholiths. The magnetic susceptibility values of the Bega Basement Terrane are the highest but the values of the magnetite-bearing rocks in the Bega Batholith decrease towards the Kosciusko Basement Terrane (Fig. 4).

There are two types of magnetite free granitoids, namely, all of the S-type granitoids, and some I-type granitoids. The magnetic susceptibility of these magnetite free I-type granitoids is slightly higher than that of the S-type granitoids, but the difference of the magnetic susceptibility between the S- and magnetite free I-type granitoids is slight. The magnetic susceptibility of the S-type

acidic welded tuff are slightly higher than those of the S-type granitoids.

In the I-type granitoids which have magnetite-free values, the magnetic susceptibilities from the Baga Batholith granitoids are the highest and that of the Melbourne Basement Terrane granitoids are the lowest over all.

In the S-type granitoids, those of the Beridale Batholith (Kosciusko Basement Terrane) have the highest magnetic susceptibility, and those of the Corryong Batholith (Wagga Basement Terrane) have the lowest. In general, the magnetic susceptibility changes abruptly at the boundaries between one terrane and another. Thus, the magnetic susceptibilities of the magnetite free granitoids reflect the chemical composition and oxidation state of the basement rocks of their basement terrane which they belong to.

Magnetic susceptibility values of the inclusions studied match those of the host rocks in many case. A chemical similarity exists between the inclusions and their host (WHITE & CHAPPELL, 1983). These facts support that most inclusions in the granitoids are considered to be restites (WHITE & CHAPPELL, 1983). However, some of the inclusions studied have different magnetic susceptibilities from their host granitoids. If the inclusions were deviated from their original composition by assimilation with melt, magnetic susceptibility differences between the host rocks and the inclusions are to be expected.

Conclusion

The magnetic susceptibility of various granitoids in the basement terranes indicates that the granitoids of each basement terrane have characteristic values.

Based on the present results and previously proposed genetic models for S-, I-, A-types granitoid (CHAPPELL & WHITE, 1974), following conclusions are obtained.

The S-type granitoids studied belong to the ilmenite-series except for a few plutons. The ilmenites of the S-type granitoids have crystallized from the magma under relatively reduced conditions than I-type granitoids. The relatively low magnetic susceptibilities support S-type granitoids were derived from

sedimentary source rocks (CHAPPELL & WHITE, 1974). On the other hand, many I-type granitoids studied belong to the magnetite-series granitoids because of their relative high oxidation state. The high magnetic susceptibility values support the I-type granitoids were derived from the partial melting of an igneous rocks source at crustal level such as basaltic andesite (WHITE & CHAPPELL, 1983).

The A-type granitoids studied belong to the ilmenite-series, but their magnetic susceptibility values are usually higher than that of the majority of the I-type granitoids. Their relative low magnetic susceptibilities are interpreted by the fractionation of early formed magnetite from the previous magma.

Acknowledgments We are grateful to Drs. R. C. PRICE and P. FLEMMING of La Trobe University in Australia for arrangement of a field trip to collect many samples of the granitoids studied and for providing geological information.

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TAINOSHO, Y., WHITE, A. J. R., CHEN, Y. and WORMALD, R., 1988 : Regional variation of magnetic susceptibility of the Lachlan Fold Belt granitoids, southeastern Australia. *Jour. Geol. Soc. Japan*, **94, 657–668.** (田結庄良昭, Allan J. R. WHITE, Yadong CHEN and Richard WORMALD, 1988 : オーストラリア南東部, Lachlan 褶曲帯の花崗岩の帯磁率の広域的变化. *地質雑*, **94**, 657–668.)

I タイプ・S タイプ花崗岩の模式地であるオーストラリア南東部 Lachlan 褶曲帯の花崗岩の帯磁率の測定を行った。S タイプ花崗岩は Kosciusko Basement Terrane の一部を除くと、すべてチタン鉄鉱系に属する。一方、I タイプ花崗岩はチタン鉄鉱系と磁鉄鉱系の両系列に属する。I タイプ花崗岩の中でチタン鉄鉱系の帯磁率は S タイプ花崗岩の帯磁率よりやや高い値を持つ。また、A タイプ花崗岩はチタン鉄鉱系と磁鉄鉱系の境界付近の帯磁率を有する。花崗岩の帯磁率は各 basement terrane ごとに特徴を持つ。最も東部の Bega Basement Terrane はすべて磁鉄鉱系の I タイプ花崗岩であり、西の I–S line に近づくにつれて帯磁率は減少する。一方、I–S line の西の Kosciusko Basement Terrane では唯一、S タイプの一部に磁鉄鉱系花崗岩がみられる。さらに、西の Howqua, Melbourne の両 Basement Terrane は I タイプ、S タイプ花崗岩ともチタン鉄鉱系である。このように、帯磁率は花崗岩の属する Basement Terrane の基盤岩の化学組成や酸化状態を反映する。