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THE MAIN DARTMOOR GRANITES: PETROGENESIS AND COMPARISONS WITH THE CARNMENELLIS AND ISLES OF SCILLY GRANITES

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The sequence CGM- (megacrystic), PM- (poorly megacrystic), FG- (fine-grained) granite in the Dartmoor pluton is magmatic and broadly follows the variation patterns already observed in the Carnmenellis and Isles of Scilly plutons. Like these, the Dartmoor granites contain high trace-alkalies, Nb, F, Sn, U and Th, which, together with high $\delta^{18}0$, suggest a crustal S-type source. However, unlike these granites, the CGM-granite of Dartmoor is more basic, has a lower initial ^{87}Sr/^{86}Sr ratio, higher total REE, flatter REE patterns, and metaluminous to peraluminous basic microgranite (BM-granite) enclaves that contain occasional hornblende and titanite. These more I-type characteristics suggest the participation of a minor, but important, subcrustal component. Continuity in several features with BM-granites indicates transition from granitoids with some I-type to dominantly S-type features. Additional evidence for an important, but subordinate, subcrustal role is provided by the associated nearby Permian volcanism and Li-mica granite and recent isotope data.

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INTRODUCTION

The Cornubian granites are typically peraluminous, have high initial ^{87}Sr/^{88}Sr, are rich in trace-alkali elements, F, Nb and Sn and are considered to be highly evolved S-type granites (Darbyshire and Shepherd, 1985; Floyd *et al.,* 1993). However, the coarse megacrystic biotite granite of the Dartmoor pluton appears to be more basic and less peraluminous than the main granites of the Carnmenellis and Isles of Scilly plutons. This paper examines the geochemistry of the main Dartmoor granites, compares these with the principal (outer) granites of the Carnmenellis and Isles of Scilly plutons and attempts to contribute towards a petrogenetic solution.

In the Dartmoor pluton, the mainly marginal coarse-grained megacrystic biotite granite (CGM) appears to grade into poorly megacrystic biotite granite (PM) (Edmonds *et al,* 1968; Ward *et al.,* 1992). Some fine-grained granites (FG) occur as dykes and sheets in both CGM- and PM-granites. Basic microgranites (BM) occur as inclusions in CGM-granite.

CHEMICAL DATA

Chemical differences between rock types are apparent in Table 1. Cluster analysis (not shown here) indicates considerable overlap of compositions with the exception of the BM-granites. Plots (Figure 1) indicate extent of overlap (in terms of standard errors) and show broad trends, despite overlap, in what is believed to be a time series (BM-, CGM-, PM- and FG-granite). For consistency, this figure uses Exeter data based upon the field classification of Heath (1982), supplemented for major elements with the data of Brammall and Harwood (1932), except in Figure la, where data from recent sources are compared. TiO_2 (Figure la, b), tFeO (Fig. 1c) and other oxides, together with trace elements such as Zr (Figure 1d) and Ce of the 'femic' suite show the usual expected decreases in the presumed time series from CGM- to FG-granites and compare with patterns obtained from other granites in the batholith. The similar contents of Zr in CGM-and PM-granites in Figure 1d become completely separated when recent data are combined. In these examples and, in addition, in SiO_2 (Figure le), MgO, CaO, Sr, V, Ga and Ni, the BM-granites stand alone and do not appear to be part of the main sequence. This suggests either lack of relationship or, more likely, broken magmatic continuity upon transport to higher crustal levels. Most of the aluminium saturation indices (ASI) for the BM-granites (Figure 1f) are significantly lower than those of the later granites, although there is some transition.

Constituents having similar patterns of variation in time (e.g. TiO_2, tFeO and Zr; Figure 1) are highly correlated and show clear positive trends in bivariate plots. Two groups are apparent in the correlation matrix (not shown), namely, the strongly associated femic' constituents (TiO_2, tFeO, MgO, CaO, Zr, Sr, V, Mn, Ba, Ce, Pb and Ni) and the trace-alkali suite (Li, Rb, and Cs, with more weakly associated U, Ga and Nb). Zr vs TiO_2 (Figure 2a) and tFeO vs TiO_2 (Figure 2b) illustrate the expected near-linear variation between members of the `femic' suite. Zr vs Nb (Figure 2c) clearly discriminates the Li-mica granites, including the nearby Meldon microgranite, from the biotite granites. The latter have an almost linear trend at near constant Nb and illustrate a marked decrease in Zr with time, consistent with zircon fractionation. Cs vs Li (Figure 2d) shows, with one exception, a fall in these elements in the FG-granite 'differentiates', like that in both the Carnmenellis and Isles of Scilly plutons, which is at variance with the marked increases in the Li-mica granites *(cf.* Stone, 1992, Fig. 3b).

COMPARISON WITH CARNMENELLIS AND ISLES OF SCILLY GRANITES

According to the map of Dangerfield and Hawkes (1981, Fig. 1), CGM- and PM-granites, which make up most of the Dartmoor pluton, are absent in the Carnmenellis and Isles of Scilly plutons. The latter consist predominantly of granites with small megacrysts, i.e. the Gm-type of Dangerfield and Hawkes (1981), as opposed to their large megacryst GM-type (CGM-granite of this paper) in Dartmoor. Moreover, inclusions of BM-granite, which are common in the Dartmoor pluton are rare or absent in the Carnmenellis and Isles of Scilly plutons.

Almandine garnet and cordierite, locally important in the Dartmoor pluton, are uncommon in the Carnmenellis and Isles of Scilly granites, though cordierite, usually associated with pelitic material, is found in some Carnmenellis samples. Andalusite is common in the Carnmenellis outer granite, less abundant in the Isles of Scilly outer granite, and uncommon in the Dartmoor granites. In addition to the usual accessory minerals common to all the biotite granites of the Cornubian batholith, titanite and hornblende occur in some BM-granite xenoliths (Brammall and Harwood, 1932). Published data for biotites from CGM-, PM- and FG-granites (Al-Saleh *et al.,* 1977; Brammall and Harwood, 1932) indicate

	1	2	3	4	5	6	7
	0565	0567	0569	CGM	PM	FG	Meldon
Wt.%							
SiO_2	68.3	63.3	67.7	73.24	75	76.67	72.8
TiO_2	0.73	1.15	1.13	0.29	0.2	0.05	0.04
Al_2O_3	13.9	14.7	13.5	14.01	13	14.52	16.4
Fe_2O_3	1.17	1.62	1.30	0.85	0.9	0.53	0.84[1]
FeO	3.17	4.65	4.54	1.47	1.3	0.25	-
MgO	1.00	3.20	1.12	0.37	0.3	0.09	0.05
CaO	2.01	3.86	2.67	0.83	0.6	0.41	1.28
Na_2O	3.44	2.58	3.77	3.03	2.9	2.79	2.77
K_2O	4.47	2.35	2.11	5.11	5	5.5	3.95
P_2O_5	0.34	0.19	0.31	0.21	0.2	0.12	0.48
F	0.23	0.27	0.26	-	-	-	1.40
Lol	0.78	0.87	1.24	-	-	-	-
Total	99.60	99.10	99.9	99.54	100	101.00	100.91
ppm							
Nb	22	12	29	17	18	12	67
Zr	265	182	218	128	122	41	38
Y	46	35	42	36	37	22	-
Sr	93	195	85	65	35	30	47
Rb	504	242	356	503	604	559	2293
V	27	125	65	11	7	2	-
Mn	760	2528	1090	410	478	257	697
Ba	335	439	127	235	150	90	197
La	49	34	30	33	39	6	15
Ce	120	82	72	52	55	nd	27
U	8	5	3	17	31	27	24
Th	29	16	13	30	28	17	-
Ga	22	19	24	17	16	17	35
Cs	44	45	71	51	65	41	223
Sn	23	11	26	16	18	10	14
Li	365	435	505	368	439	192	6502
K/Rb	73.6	80.6	49.2	87.8	71.0	94.2	14.0
Rb/Sr	5.4	1.2	4.2	12.3	26	125.0	48.8
ASI	1.04	1.10	1.07	1.22	1.2	1.32	1.64

1-3. BM-granite xenoliths in GCM-granite, Bonehill Rocks (SW 732 775) (1) and Tunhill Rocks (SW 731 757) (2 and 3).

4. Average of 27 CGM-granites (Heath, 1982).

5. Average of 6 PM-granites (Heath, 1982).

6. Average of 4 FG-granites (Heath, 1982).

7. Li-mica microgranite, Meldon (Stone and George, 1978). Totals include MnO and Li_2O and are corrected for F where appropriate.
[1] Total Fe as Fe_2O_3. — not determined;
nd - not detected. ASI = aluminium saturation index (i.e. Al/(Ca'/2+Na+K), where Ca'=Ca-5/3P, in atoms).

	1	2	3	4	5
Rock type	PM	CGM	BM	Gm(CM)	Gm(SC)
Wt.%					
SiO_2	35.3	35.15	34.80	35.75	35.78
TiO_2	3.26	3.67	3.53	2.50	2.66
Al_2O_3	19.9	18.40	18.3	20.87	20.01
tFeO	21.40	23.88	23.5	20.88	21.63
MnO	0.36	0.48	0.54	0.38	0.45
MgO	5.09	4.65	4.84	4.84	4.29
CaO	0.02	0.02	nd	0.24	0.01
Na_2O	0.19	0.23	0.12	0.38	0.07
K_2O	9.28	9.24	9.27	9.02	9.30
Rb_2O	0.11	0.16	0.13	0.25	0.19
F	1.47	1.47	1.75	1.96	1.71
-0=F	0.61	0.61	0.74	0.83	0.72
Total	95.7	96.74	96	96.24	95.38
Formulae on basis of 22 oxygen atoms					
Si	5.44	5.452	5.45	5.485	5.551
Al(4)	2.55	2.548	2.55	2.515	2.449
Al(6)	1.060	0.814	0.81	1.261	1.212
Ti	0.38	0.428	0.42	0.288	0.312
tFe^{2+}	2.76	3.100	3.08	2.680	2.805
Mn	0.05	0.063	0.07	0.049	0.059
Mg	1.17	1.076	1.13	1.107	0.981
ΣY	5.04	5.481	5.090	5.097	5.369
Ca	0	0.003	-	0.023	0.001
Na	0.06	0.067	0.04	0.072	0.019
K	1.83	1.829	1.85	1.767	1.883
Rb	0.01	0.016	0.01	0.024	0.018
ΣX	1.9	1.915	1.9	1.885	1.870
F	0.72	0.720	0.87	0.881	0.839
tFe*	0.7	0.744	0.73	0.708	0.741
ASI	1.91	1.758	1.77	2.025	1.958
n	11	46	20	47	34

1. Average biotite from PM-granite, Haytor E. Quarry (GR SX761775)

2. Average biotite from 7 specimens of CGM-granite.

3. Average biotite from 3 specimens of BM-granite.

4. Average biotite from 11 specimens of Carnmenellis outer granite.

5. Average biotite from 5 specimens of Isles of Scilly outer granite: Sum includes Cs_2O=0.07, Cl=0.05 (Stone and Exley, 1989, Table 1, col. 2). nd = not detected; n = total number of points analyzed; ASI = aluminium saturation index (see Table 1). Al(4) and Al(6) =Al in tetrahedral and octahedral sites respectively. tFeO = total iron as FeO; tFe = total iron as Fe^{2+}. *Fe = $Fe^{2+}/(Fe^{2+}+Mg)$

siderophyllite compositions with low Li contents (< 0.5 atoms on basis of 24 O, OH, F). New data for Dartmoor biotites (Table 2) reveal lower Rb than typical lithian siderophyllites in the Carnmenellis and Isles of Scilly granites (cf. Stone and Exley, 1989, Table 1) and have lower total Al and octahedral Al. They are also significantly richer in Ti and tFe.

Geochemical comparisons between the outer (Gm-)granites of the Isles of Scilly and Carnmenellis plutons on the one hand, and the CGM-granites of Dartmoor on the other, show similarities in major oxides between the former granites and some marked differences in major and trace elements between these and Dartmoor. For example, many Dartmoor samples are markedly richer in TiO_2 (Figure 3a), tFeO, MgO and CaO and trace elements such as Nb, Zr (Figure 3b), Y (Figure 3c), Mn and Sr, but have lower ASI values (Figure 3d) compared with the other two plutons. However, the Dartmoor PM-granites compare more closely with the Gm-granites in several femic constituents *(cf.* Stone, 1992, Fig. 2: where DT1 = CGM-granite and DT2 = PM-granite; CM1 and SC2 are outer (Gm-) granites from the Carnmenellis and Isles of Scilly plutons respectively), although there are also marked differences (e.g. MgO, Sr, Ce and Y). On a multivariate level, linear discriminant analysis using all 31 analyzed major and trace elements shows much closer similarity (smaller squared distance, d^2) between the Carnmenellis and Isles of Scilly Gm-granites and a marked difference between these and the Dartmoor CGM-granite (a larger d^2 - about five times greater).

Darbyshire and Shepherd (1985) found that the granites of Dartmoor, St. Austell and Land's End have lower Ce_N/Yb_N ratios than those of Bodmin Moor and Carnmenellis. REE data for the average outer granites of Carnmenellis (compiled from Darbyshire and Shepherd, 1985; Jefferies, 1985; Stone, 1987) and the Isles of Scilly (Stone and Exley, 19.89, Table 3) are similar, but differ from the Dartmoor data (Figure 4). The higher HREE content of the Dartmoor rocks is predicted from their higher Y contents (Figure 3c) and is seen in their higher total REE (tREE) and significantly lower Ce_N/Yb_N ratios (Table 3), in accord with the observations of Darbyshire and Shepherd (1985). Slopes (m of Table 3) of the regression lines on the logarithms of the normalized LREE (first 6 points, excluding Eu) show that, even at the LREE end, Dartmoor samples have markedly lower slopes than those from the other two plutons. As in the other plutons, the more evolved PM- and FG-granites of Dartmoor have lower slopes than the earlier (less evolved) members.

PETROGENESIS

Variation patterns

Similarities in the granitoid rocks of the Cornubian batholith indicate a common origin. Decreasing tREE and Ce_N/Yb_N and the typical pattern of decreasing 'femic' oxides/elements in the 'time series' CGM-, PM- and FG-granites suggest magmatic differentiation by removal of biotite and the principal accessory minerals, especially monazite, together with dominant feldspar (mainly plagioclase) fractionation (Stone, 1992, Fig. 6) either during magma ascent (Stone and Exley, 1989) or by progressive crystallization from the walls of the pluton (Ward *et al.,* 1992). The more basic and primitive nature of the Dartmoor BM- and CGM-granites and their biotites compared with the Carnmenellis and Isles of Scilly outer granites indicate either an earlier stage of evolution exposed on Dartmoor or, more likely, as indicated below, different source components or different proportions of those components.

Source

Initial $^{87}Sr/^{86}Sr$ (0.7101; Darbyshire and Shepherd, 1985) and high $\delta^{18}O$ *(c.* 11; Sheppard, 1977) together with the occurrence of cordierite and co-existing almandine garnet at some localities suggest a lower crustal source (Stone, 1988) with an important pelitic component for Dartmoor CGM-granite. However, several features in the Dartmoor BM- and CGM-granites compared with the Carnmenellis and Isles of Scilly granites point to different source components or different amounts of these in the Dartmoor pluton compared with the other two granites. These include (i) the higher 'femic' contents of the former, (ii) the fact that the CGM-granites (of Heath, 1982; Darbyshire and Shepherd, 1985; Ward *et al.,* 1992) in the Dartmoor pluton plot close to or within the `within-plate granite' field of Pearce *et al.* (1984), whilst the Carnmenellis and Isles of Scilly granites plot well within the 'syn-collision granite' field *(cf.* Stone, 1990, Fig. 4), (iii) the flatter REE patterns of the Dartmoor rocks, (iv) the microgranite inclusions and, (v) the recently published ε_{Nd} data of Darbyshire and Shepherd (1994), which includes -4.7 for Dartmoor, compared with c. -7.0 for Carnmenellis.

The difference in ferric constituents could indicate different sampling levels in the batholith rather than different sources, but both Dartmoor and Godolphin (with similar chemistry) lie close to their original roofs and the latter lies adjacent to the Carnmenellis granite.

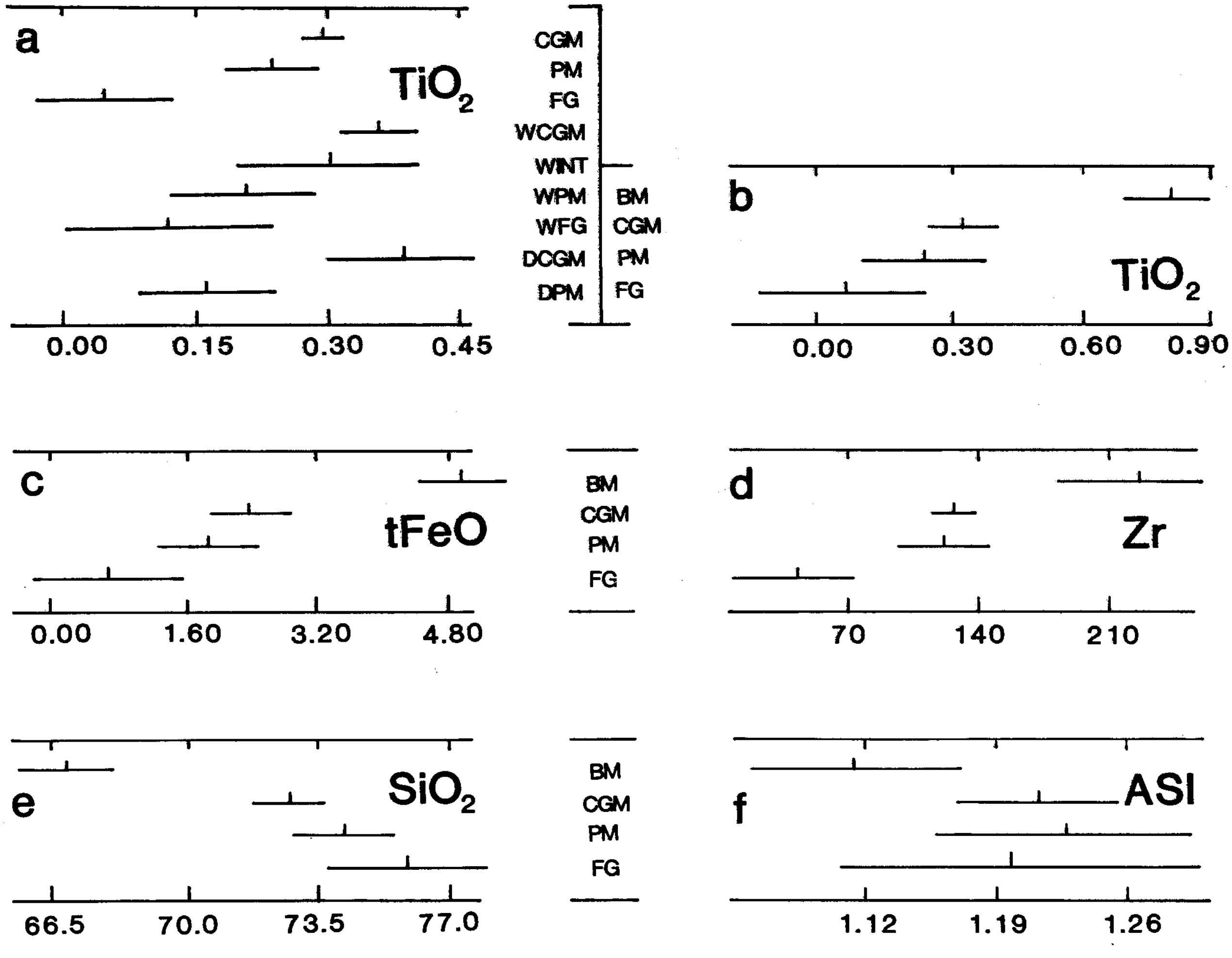

Figure 1. Means and 95% confidence limits (Minitab Oneway Analysis of Variance ouput). BM basic microgranite; CGM- coarse-grained megacrystic biotite granite; PM = poorly megacrystic biotite granite; FG = fine-grained granite. (a) TiO_2*[CGM-, PM-and FG-granites (Exeter data) compared with the data of Ward et al. (1992) including their INT-granites - symbols preceded by W. Those preceded by D are the CGM- and PM-granites of Darbyshire and Shepherd (1985); (b)* TiO_2*; (c) tFeO; (d) Zr; (e)* SiO_2*; and ASI* (cf. *Table 1). 1 b, c, e and f include the data of Brammall and Harwood (1932), which increase the number of BM- and FG-granites (from 3 to 20 and 4 to 7 respectively). Similar patterns are obtained using data from single or combined sources.*

whether or not the Nb vs Y diagram is capable of tectonic discrimination, there is a clear chemical discrimination between the Dartmoor and the other two granites and source differences are implied.

REE patterns

The flattening of patterns as a result of falling Ce_N/Yb_N in a granitoid sequence indicates monazite fractionation, principally as a result of fractionation of biotite, in which much of the monazite is included (Miller and Mittlefehldt, 1982; Stone, 1987). Flattening is also accompanied by falling tREE. However, even the earlier Dartmoor granite samples have flatter patterns *and* higher total REE than those from the Carnmenellis and Isles of Scilly outer granites. The difference is probably the result of a higher zircon content in the former, as indicated by higher Zr content, and the occurrence of some xenotime (Ward *et al.,* 1992), as in the Lundy granite (Stone, 1990; Thorpe *et al.,* 1990). The very flat pattern of the Lundy granite, combined with high tREE, is typical of several other Tertiary granitoids (e.g. Arran) and the Mull sequence of evolution from basic to acid volcanic rocks (Walsh and Clarke, 1982), suggesting that such flat patterns may have been generated during evolution of basic granitoids that, in turn, were fractionates of basic magmas.

Microgranitoid inclusions

These inclusions in S-type granitoids of the Lachlan fold belt (Chen *et al,* 1989) and elsewhere are markedly peraluminous and commonly contain cordierite, in direct contrast with the more basic Dartmoor inclusions. The latter contain rare hornblende and titanite (recorded by Brammall and Harwood, 1932, and observed by the author), and have typical ASI values close to 1. Such features suggest the presence of an I-type component in the more basic Dartmoor BM-granites. The more granitic inclusions show a wide spread of ASI values, perhaps pointing to one or more of the following: (i) variable equilibration with the host magma *(cf* Van der Laan and Wyllie, 1993); (ii) sampling of a wide range of earlier unexposed contrasting granitoids that have some I-type features associated with true S-type granites, as in the Lachlan fold belt of south-eastern Australia (White and Chappell, 1988); (iii) an evolution from metaluminous or subaluminous to peraluminous granitoid magma that culminated in the CGM- and PM-granites.

Participation of more basic magma at an earlier stage is implied (Vernon, 1984; Poli and Tommasini, 1991) in the more prominent I-type features of the basic Dartmoor inclusions, perhaps involving magma mixing that generated intermediate (dioritic) magma which subsequently differentiated to give the present range of compositions in the inclusions. Such a differentiation trend could be readily effected by initial hornblende fractionation followed by dominant feldspar fractionation once the ASI value exceeded 1 (Zen, 1986). Although Clark *et al.* (1993) and others interpret these enclaves as "pillows" of hybrid melts, the sheet-like rafts at Bellever Tor [SX 644 764] and Birch Tor [SX 687 816] resemble true xenoliths of pre-existing more basic granitoid that could have been generated at an earlier stage of magma mixing.

Table 3. REE data: Dartmoor, Carnmenellis and Isles of Scilly

	1	2	3	4	5	6
Rock type	Gm	Gm	BM	CGM	CGM	PM
La	31.29	37.66	38.13	29.63	31.38	13.61
Ce	63.76	75.17	73.23	62.57	64.71	30.51
Pr	7.27	7.51	8.74	8.15	7.44	4.09
Nd	27.49	30.34	38.85	28.86	28.16	14.48
Sm	5.35	5.13	8.10	5.73	5.63	3.31
Eu	0.74	0.72	0.86	0.69	0.75	0.16
Gd	3.65	3.31	7.28	4.61	4.77	2.91
Dy	2.35	2.07	6.37	4.38	4.29	3.32
Ho	0.38	0.38	1.28	0.81	0.83	0.60
Er	1.13	0.98	3.10	2.41	2.30	1.71
Yb	0.88	0.79	2.66	2.12	2.18	1.56
Lu	0.12	0.12	0.37	0.34	0.30	0.23
tREE	120.5	143.40	188.9	150.30	152.7	76.49
Ce_N/Yb_N	18.77	24.77	7.13	7.64	7.85	5.06
Eu_N/Eu_N*	0.49	0.50	0.34	0.40	0.43	0.15
m	-	-0.139	-	-0.106	-	-0.09
r^2	99.7	99.6	99.0	99.4	99.9	99.0

1. Average Carnmenellis outer (Gm-)granite: Darbyshire and Shepherd (1985), Jefferies (1985) and Stone (1987).
2. Average Isles of Scilly outer (Gm-)granite: Stone and Exley (1989).
3. Microgranite enclave (BM-granite, MS0569) in CGM-granite, Tunhill Rocks, Dartmoor (New analysis).
4. CGM-granite (E42059) Dartmoor:(Darbyshire and Shepherd, 1985).
5. Average of 9 Dartmoor CGM-granites (Ward *et al.,* 1992).
6. PM-granite (E44794), Dartmoor (Darbyshire and Shepherd, 1985).

tREE = total REE; N subscipt refers to chondrite-normalized values; Eu_N* = value of Eu_N interpolated between Sm_N and Gd_N. m = slope of regression lines of logarithms of normalized data points of La to Gd (excluding Eu): r^2 = percent contribution to linear regression.

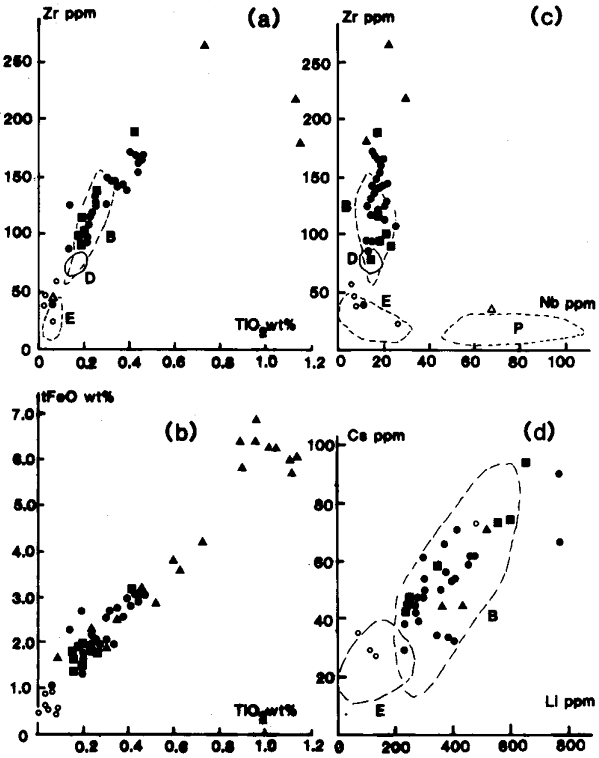

Figure 2. . Bivariate plots for the main Dartmoor granite types. a, c and d use Exeter data only; b uses these data combined with those of Brammall and Harwood (1932). Filled triangles = BM-granite; open triangle = Meldon microgranite; filled circles = CGM-granite; squares = PM-granite; open circles = FG-granite: B and E = fields of outer (Gm) granites and felsic microgranites/aplites respectively in the Carnmenellis and Isles of Scilly plutons; D = field of inner granites of Carnmenellis; P = field of Li-mica granites (Stone, 1990; Manning and Hill, 1990).

CONCLUSIONS

1. The predominance of BM-granite inclusions in the CGM-granite suggest that it was emplaced first, followed immediately and perhaps

continuously, by a slightly more evolved PM-granite magma containing few or no BM-granite inclusions. This view contrasts with that of Ward *et al.* (1992) who consider that a parent PM-granite magma gave rise to the CGM-granite magma as a marginal cumulate. Biotite and dominant feldspar fractionation during transit from the lower crust could account for the overall evolution of the biotite granites in the Cornubian batholith. However, in the case of Dartmoor, the production of an early more basic granitoid ('mixed') magma would account for the occurrence of the microgranite inclusions, and hornblende, followed by feldspar fractionation, would generate the presently exposed peraluminous granite sequence.

2. High initial $^{87}Sr/^{86}Sr$ and $\delta^{18}O$ values and the occurrence of S-type granites with cordierite and almandine in some facies, point to a significant crustal greywacke/pelite contribution. However, the transition from I- to S-type characteristics shown by the range of BM-granite inclusions and the sequence from BM-granite to S-type FG-granite imply the initial participation of a subcrustal source for the more basic inclusions. This implication is strengthened by the relatively flat REE patterns, yet high tREE and the recent Nd-isotope data (Darbyshire and Shepherd, 1994) which point to a lower crustal source of greywackes and mafic volcanic rocks with minor basaltic (mantle) material.

3. Compatibility in certain critical aspects of Dartmoor data (REE patterns and the position of the composition field in the Nb vs Y plot, together with higher overall 'femic' suite contents compared with the Carnmenellis and Isles of Scilly granites), combined I- and S-type features and transition from one to the other, together with the isotope data, favour minor contamination of palingenetic granitic magmas of lower crustal origin by basic magma before subsequent differentiation. As in the Lundy granite, the occurrence of both mantle and crustal components suggest that basalt magma underplated and intruded lower continental crust (Huppert and Sparks, 1988; Stone, 1990; Thorpe *et al.,* 1990) resulting in partial melting and the production of granitic magma that subsequently mixed with some basic magma to produce the parent from which the Dartmoor sequence was derived. A similar conclusion is reached by Clark *et al.* (1993).

4. Additional evidence for an important role of the mantle or crust/mantle interface in the generation of the rocks of the Dartmoor pluton lies in the close temporal and spatial association with Permian volcanism (Thorpe, 1987; Leat *et al.,* 1987) and the near contemporaneous Li-mica granite magmatism at Meldon. It is significant that the biotite granites of St. Austell (Darbyshire and Shepherd, 1985; Manning and Hill, 1990) and Tregonning-Godolphin (Stone, 1992) also differ geochemically from the Bodmin Moor and Carnmenellis granites but are closer in composition with the Dartmoor granites (data in Darbyshire and Shepherd, 1985; and unpublished data) and each is associated with Li-mica granites. This suggests that the genesis of some of the Cornubian plutons (Tregonning-Godolphin, St. Austell and Dartmoor) were associated with more mantle or crust/mantle interface activity than the others (Isles of Scilly, Carnmenellis and Bodmin Moor).

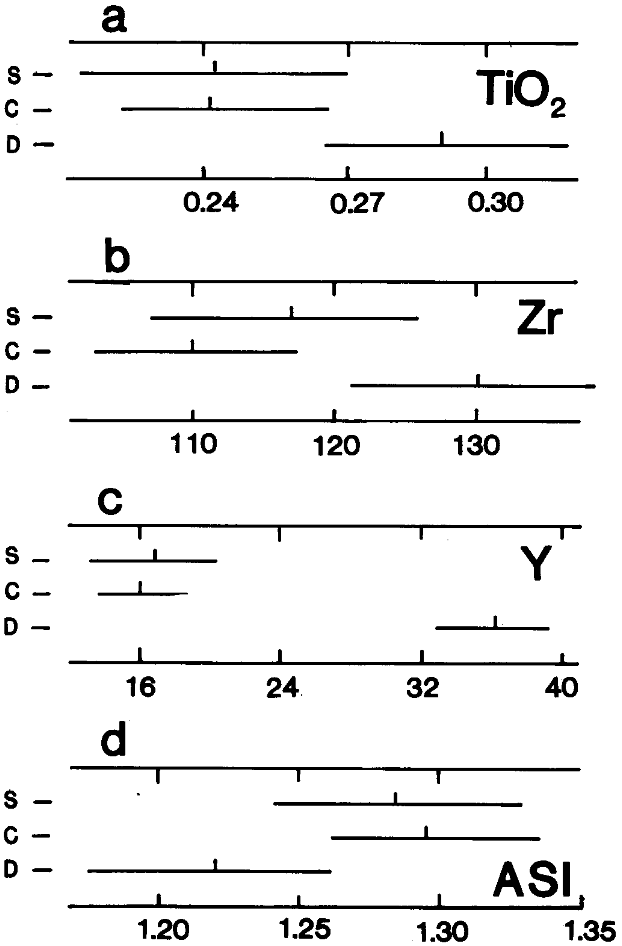

Figure 3. Means and 95% confidence intervals (from Minitab, as in Fig. 1) of TiO_2 (wt.%), Zr (ppm), Y (ppm) and ASI (cf. Table 1)for the outer (Gm) granites of Carnmenellis (C, 34 samples) and the Isles of Scilly (S, 22 samples) and the CGM-granites of Dartmoor (D, 26 samples). All data were obtained in the Exeter laboratories.

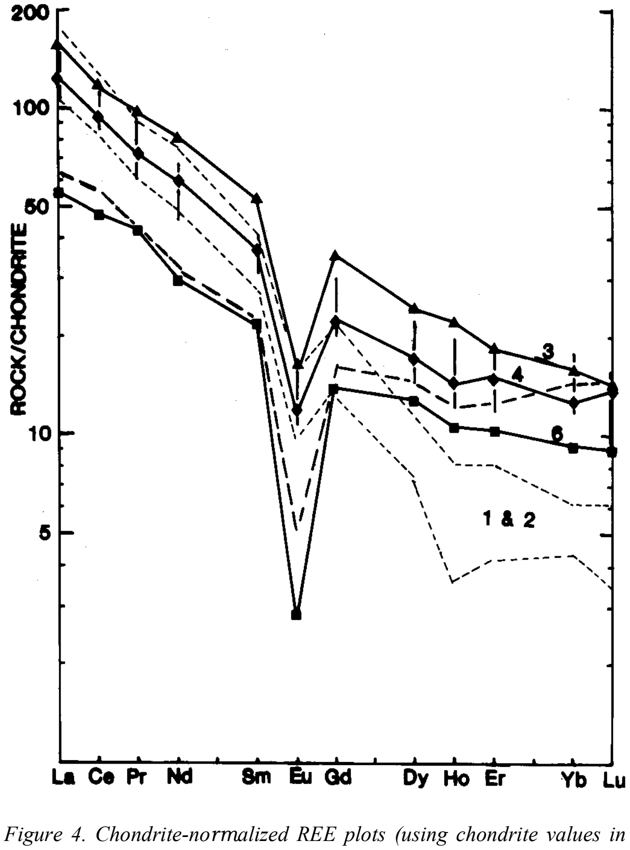

Figure 4. Chondrite-normalized REE plots (using chondrite values in Evensen et al., 1978) of Dartmoor samples (solid lines) and the range in 19 samples of outer (Gm) granites from Carnmenellis and Isles of Scilly (small-dashed lines). Numbers correspond with the columns in Table 3: 3 (triangles) = BM-granite. 4 (diamonds) = CGM-granite; 6 (squares) = PM-granite. Vertical bars give the range of 9 samples of Dartmoor CGM-granite and the long-dashed line is the average of 3 PM-granite samples (Ward et al., 1992).

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