


NGU Rapport 97.122 II

**Petrology, Lithology, Bedrock Structures,
Glaciation and Sea Level. Important Factors for
Groundwater Yield and Composition of
Norwegian Bedrock Boreholes?**

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Ytelse	Fluor		Radon	

Petrology, Lithology, Bedrock Structures, Glaciation and Sea Level. Important Factors for Groundwater Yield and Composition of Norwegian Bedrock Boreholes?

Geir Morland

May 1997

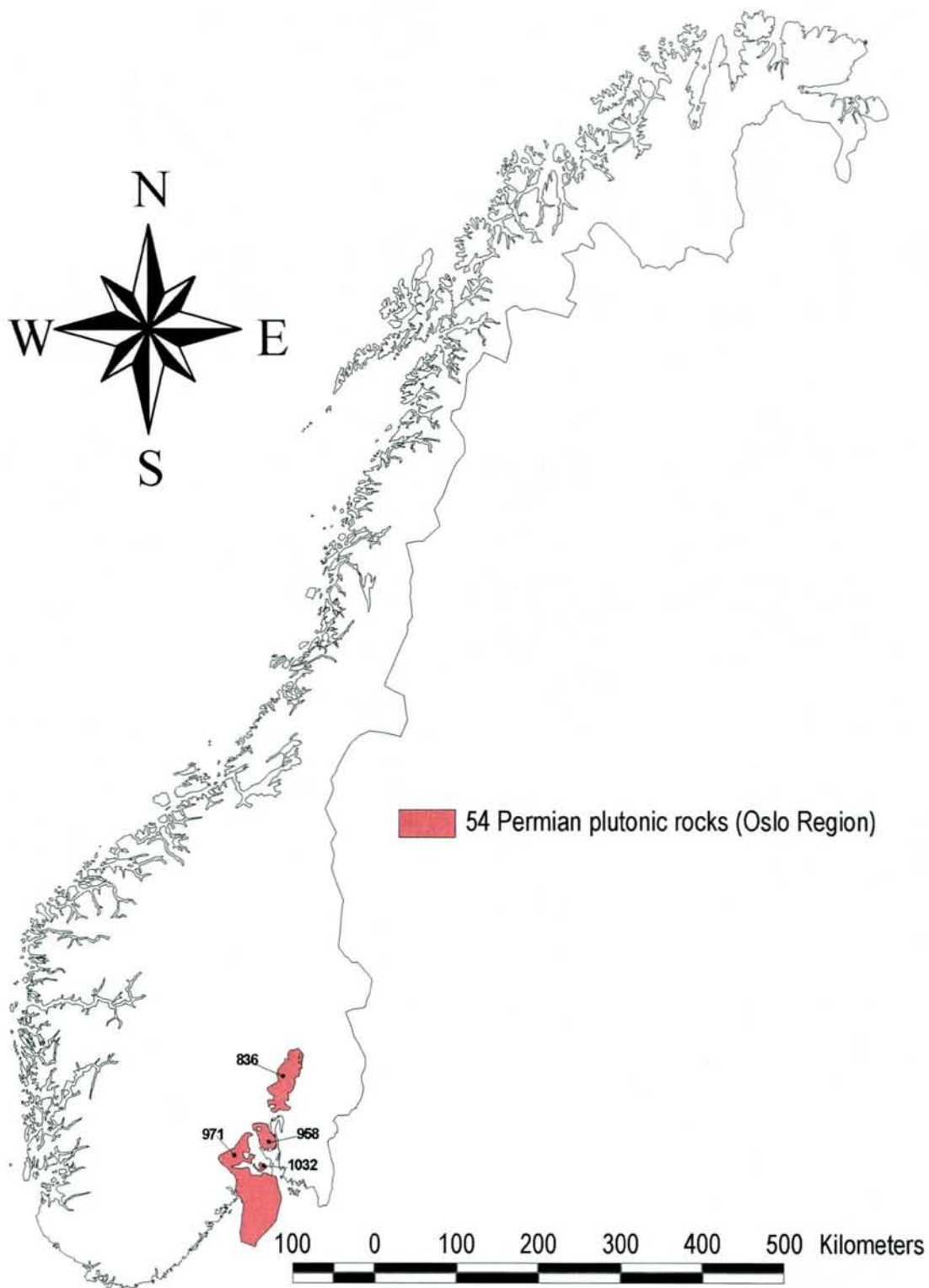
Appendices

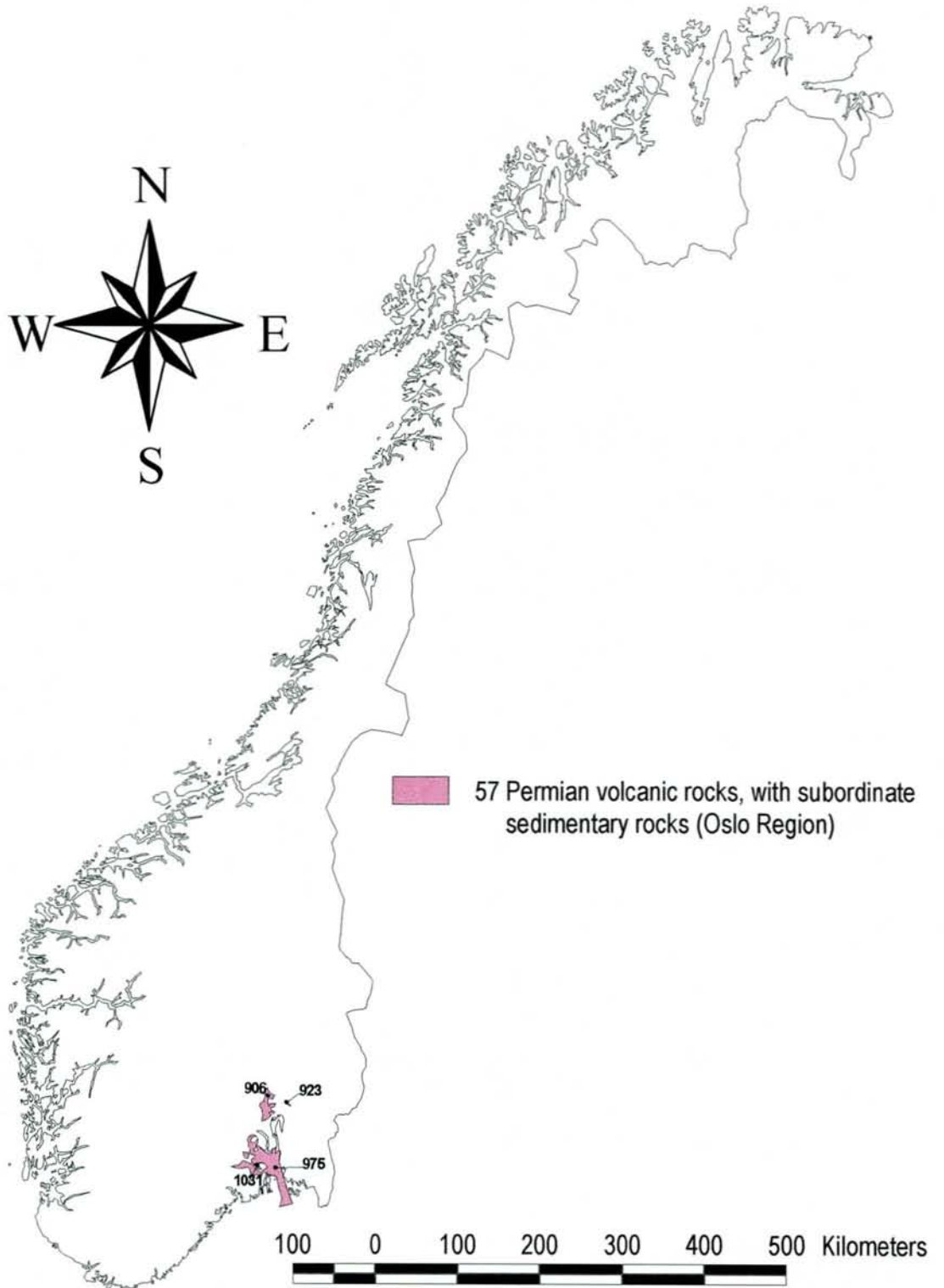
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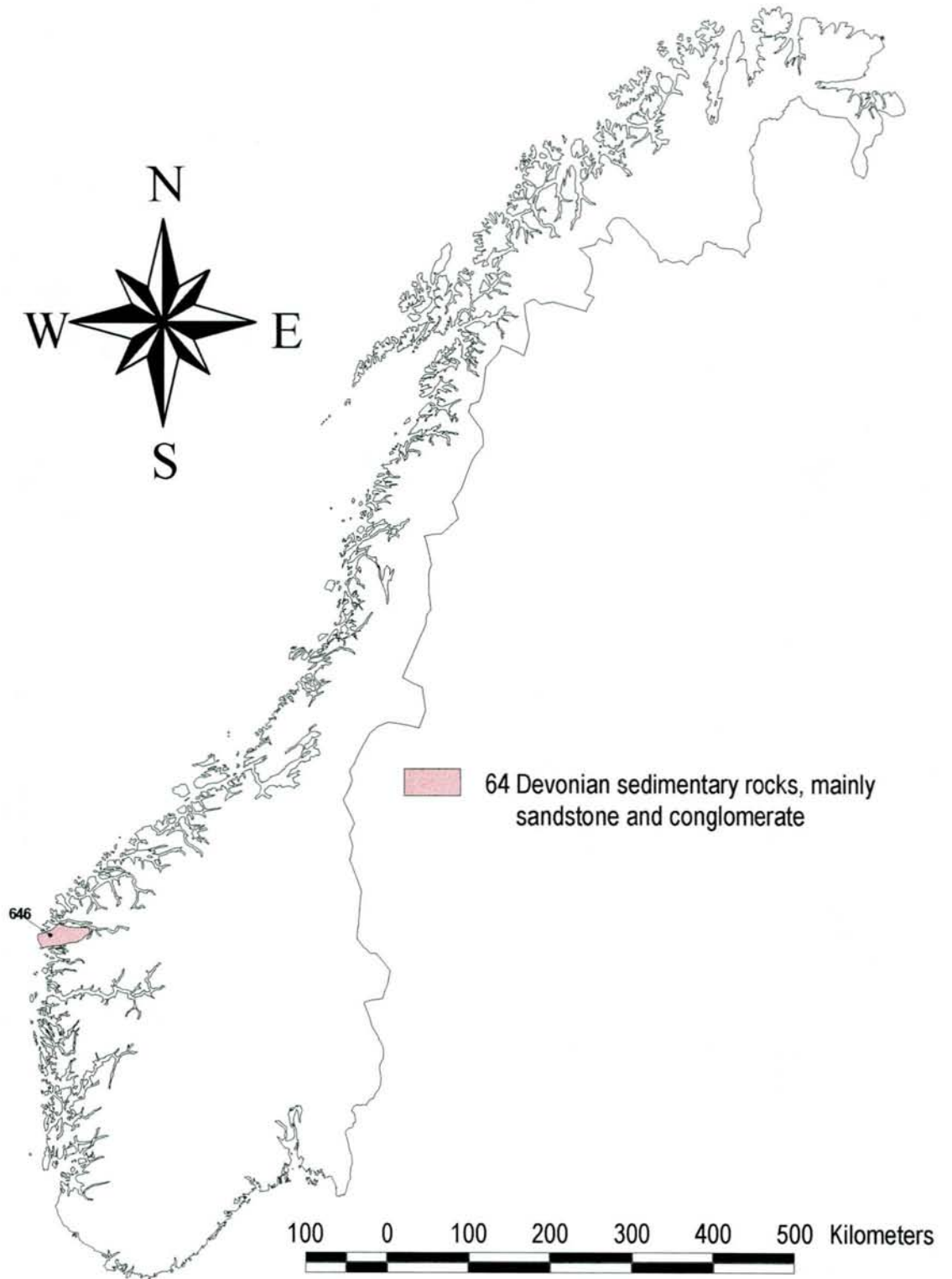
Appendix A

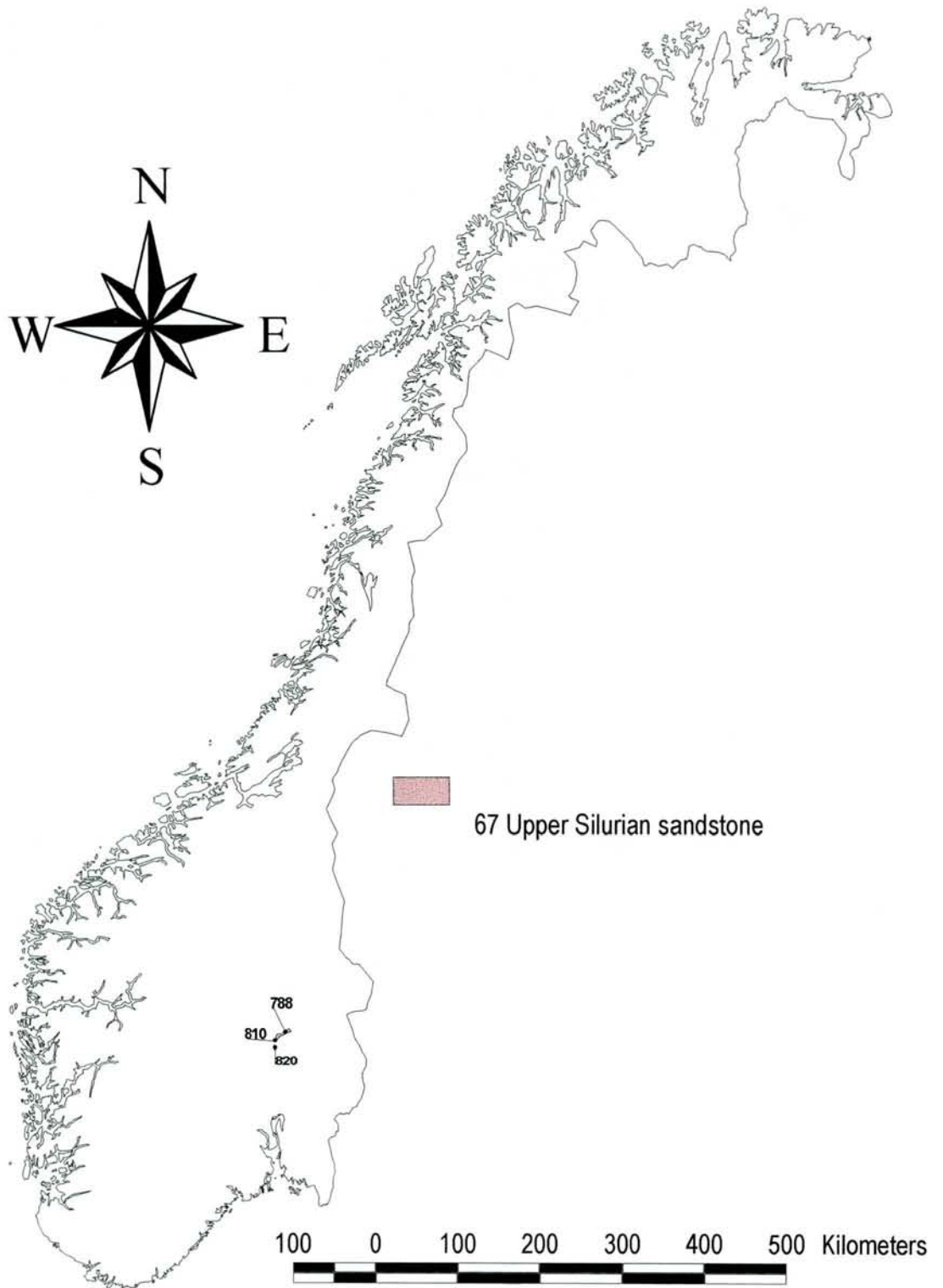
Location of different rocktypes and entities

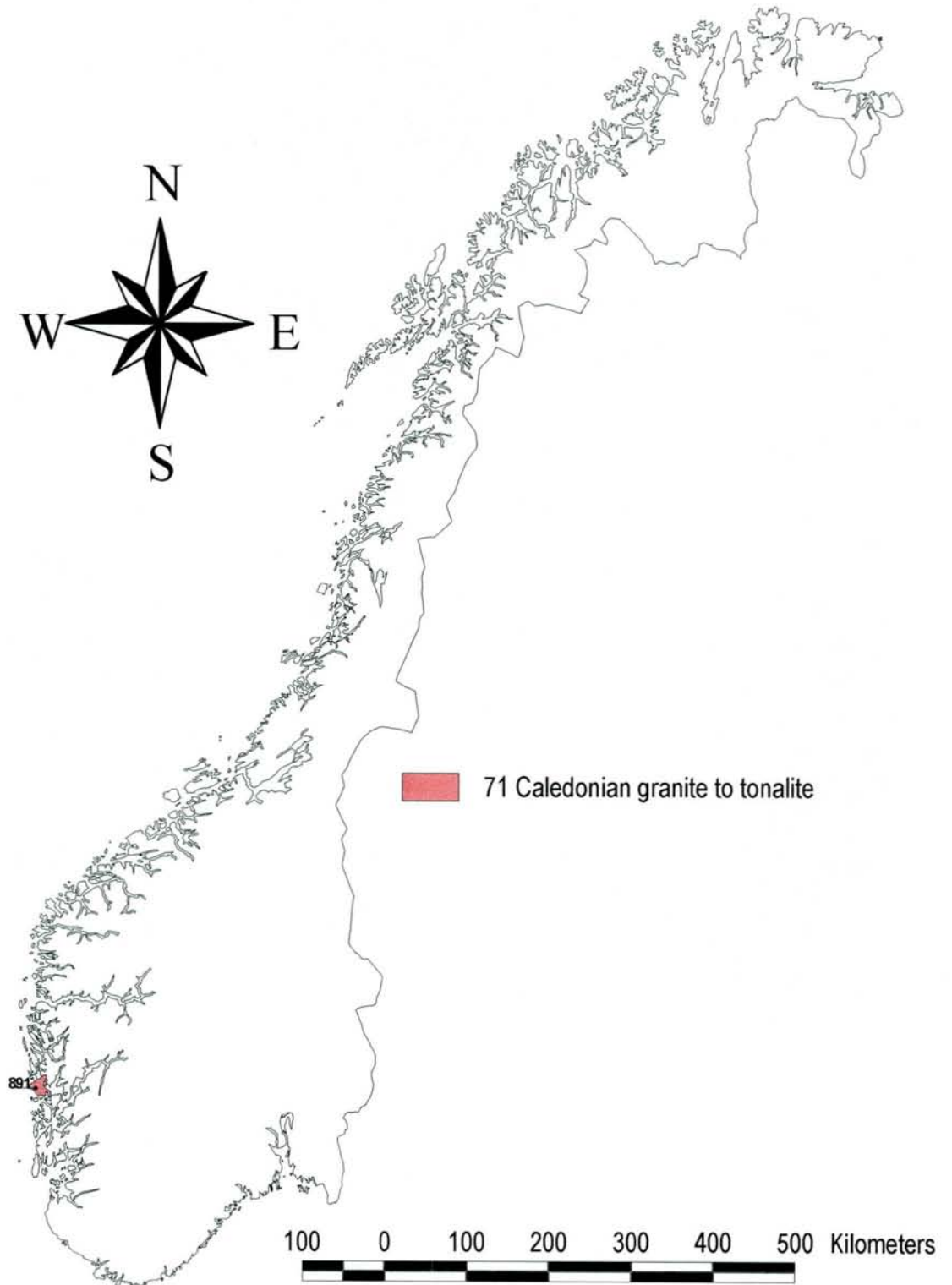
Numbers refer to entity number, see Table 2.3.1 and Appendix E.

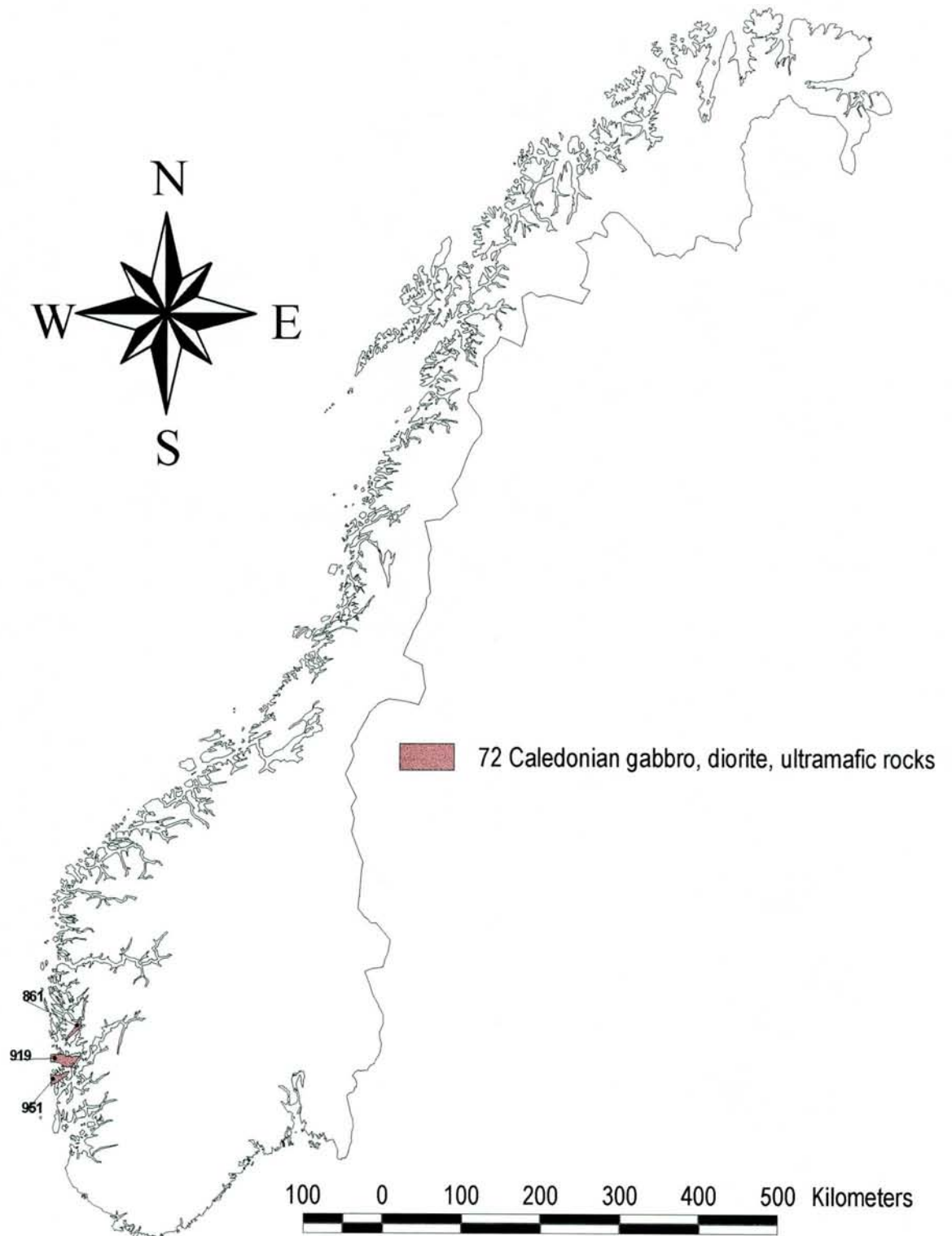


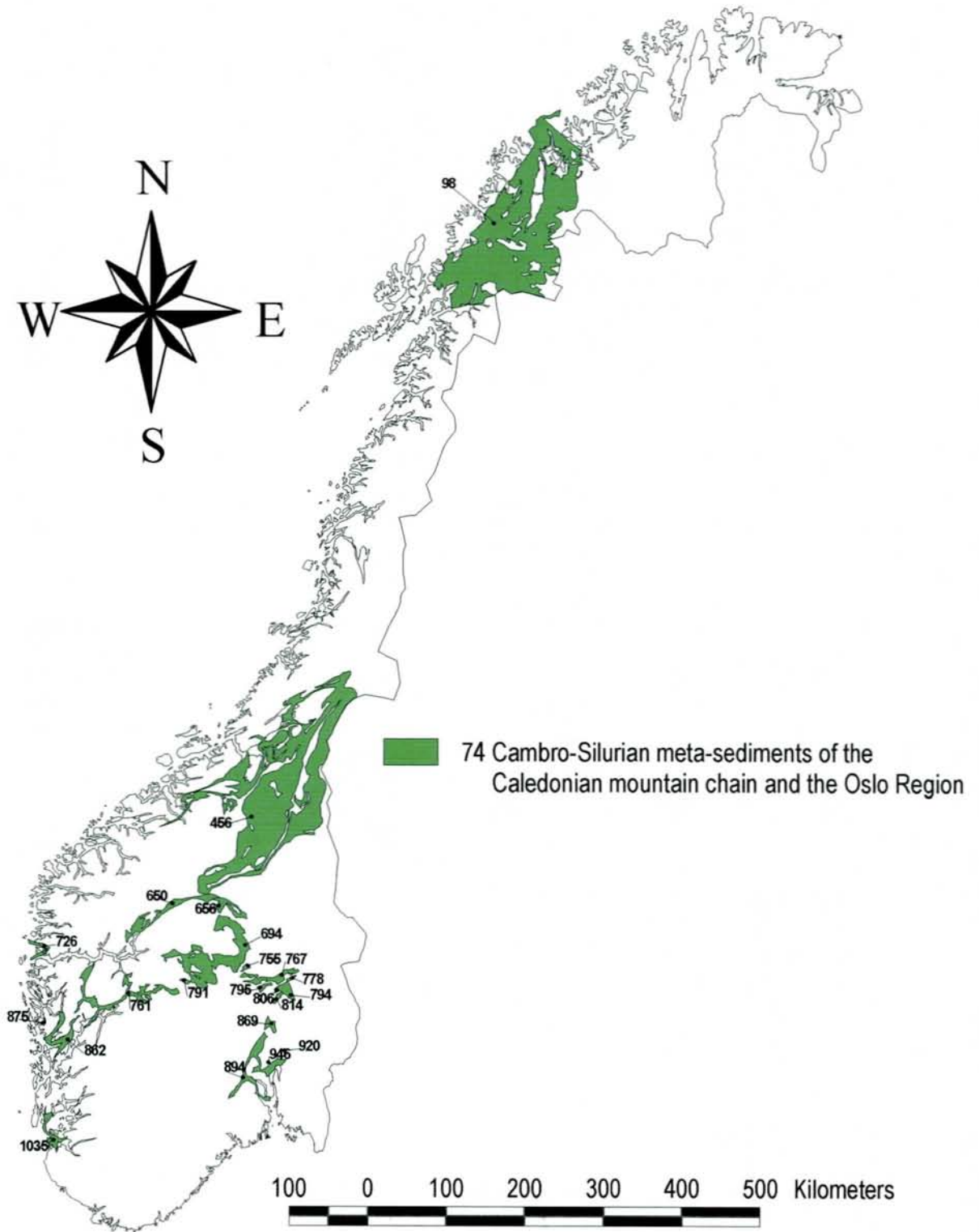


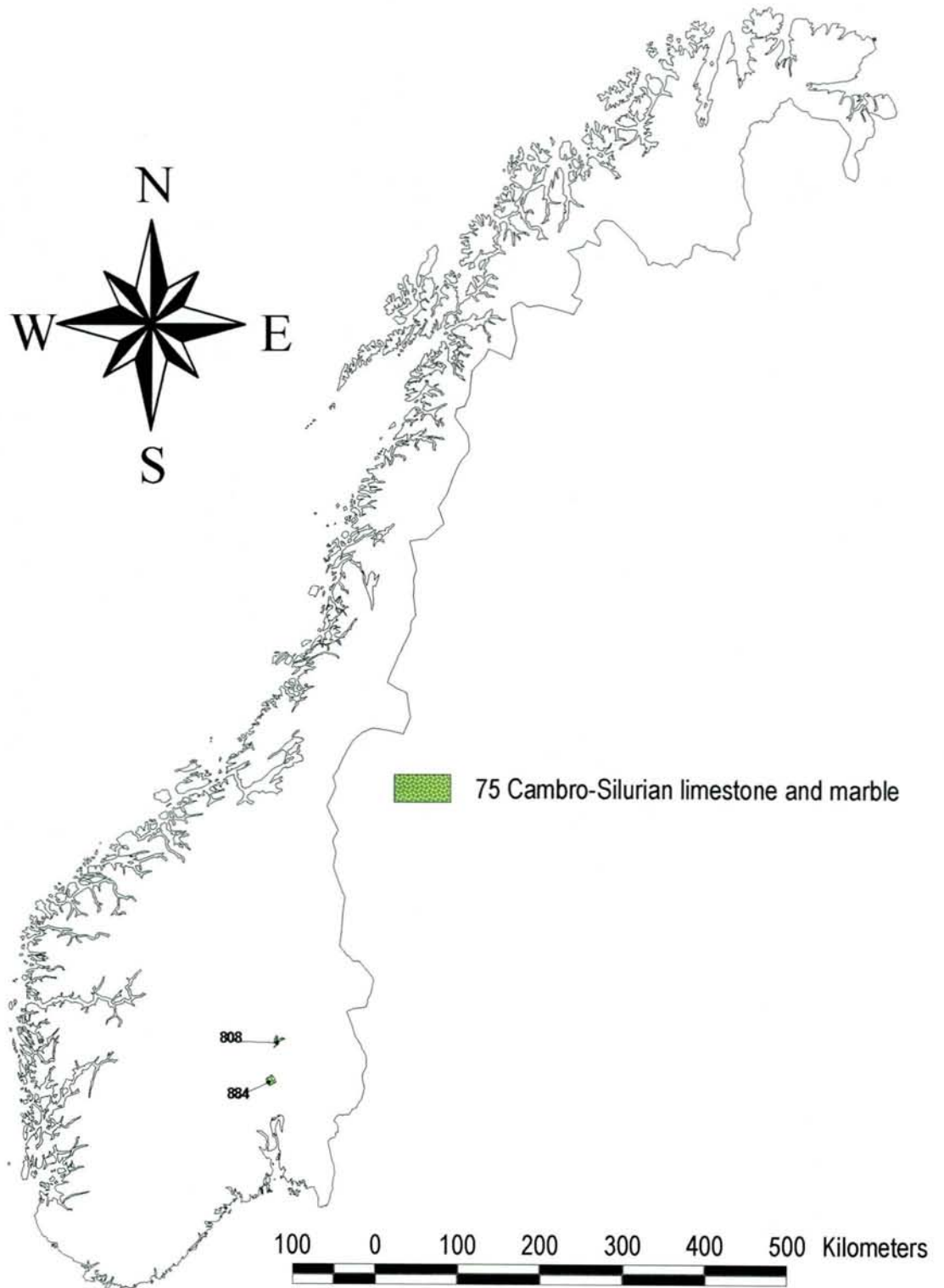


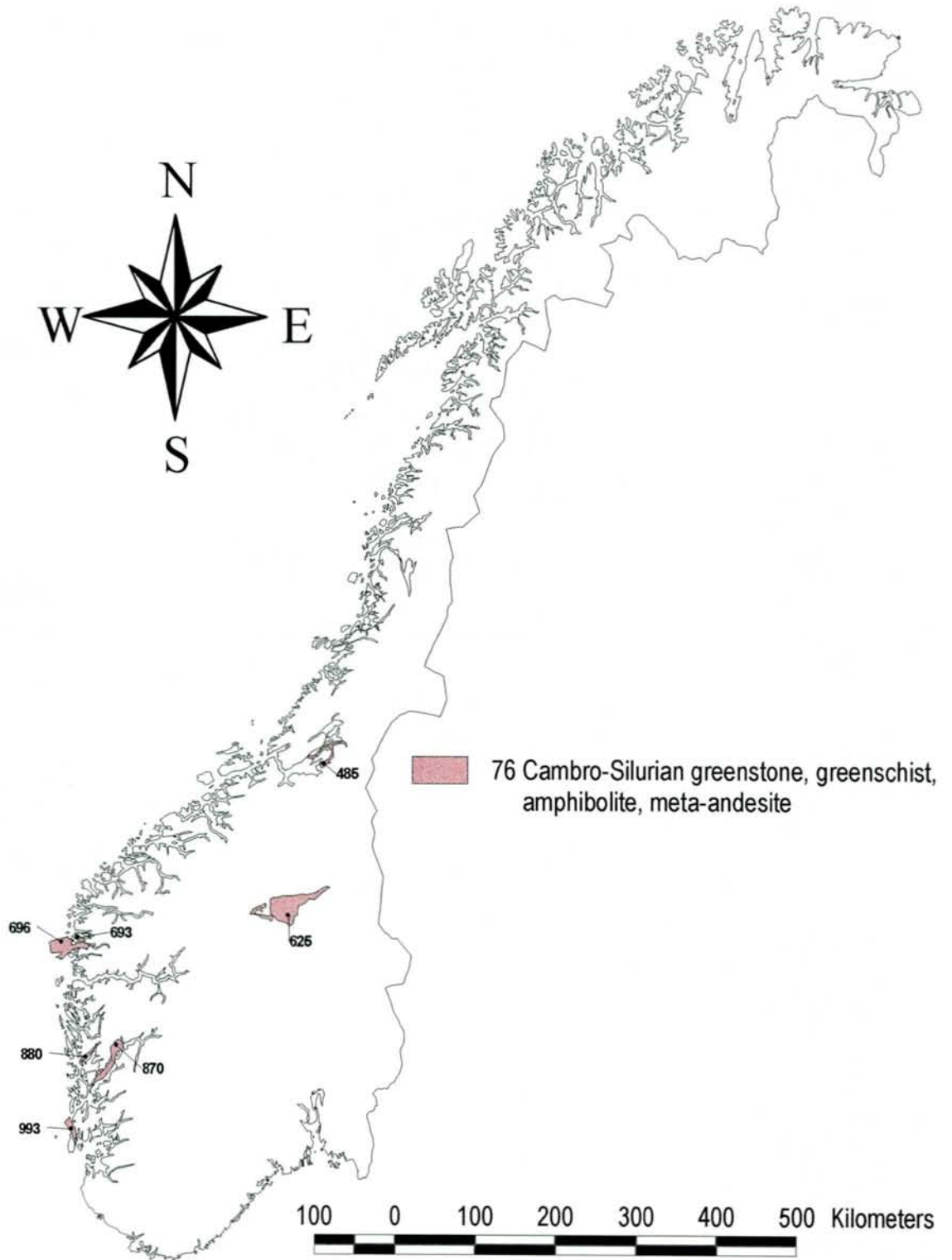


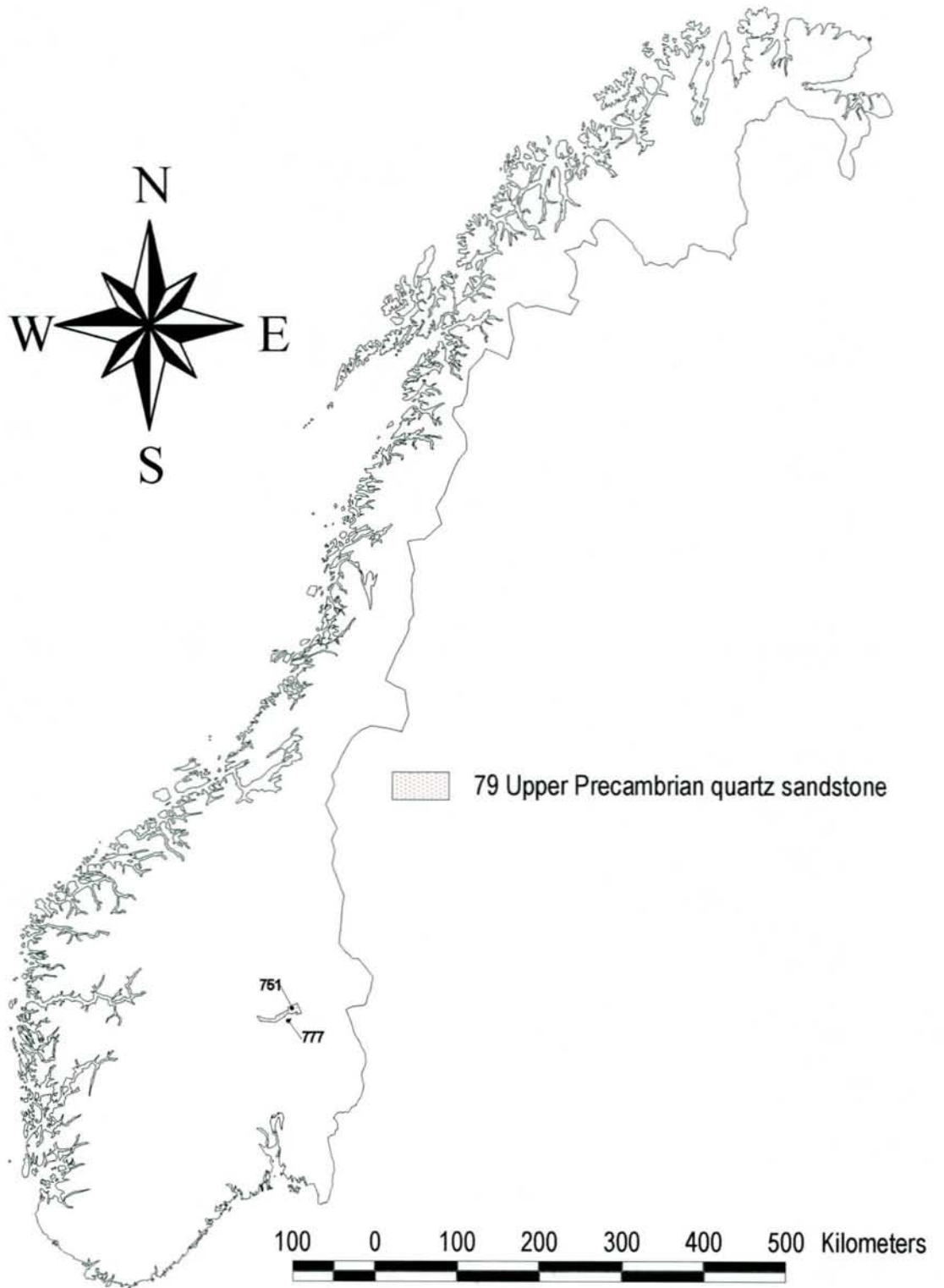


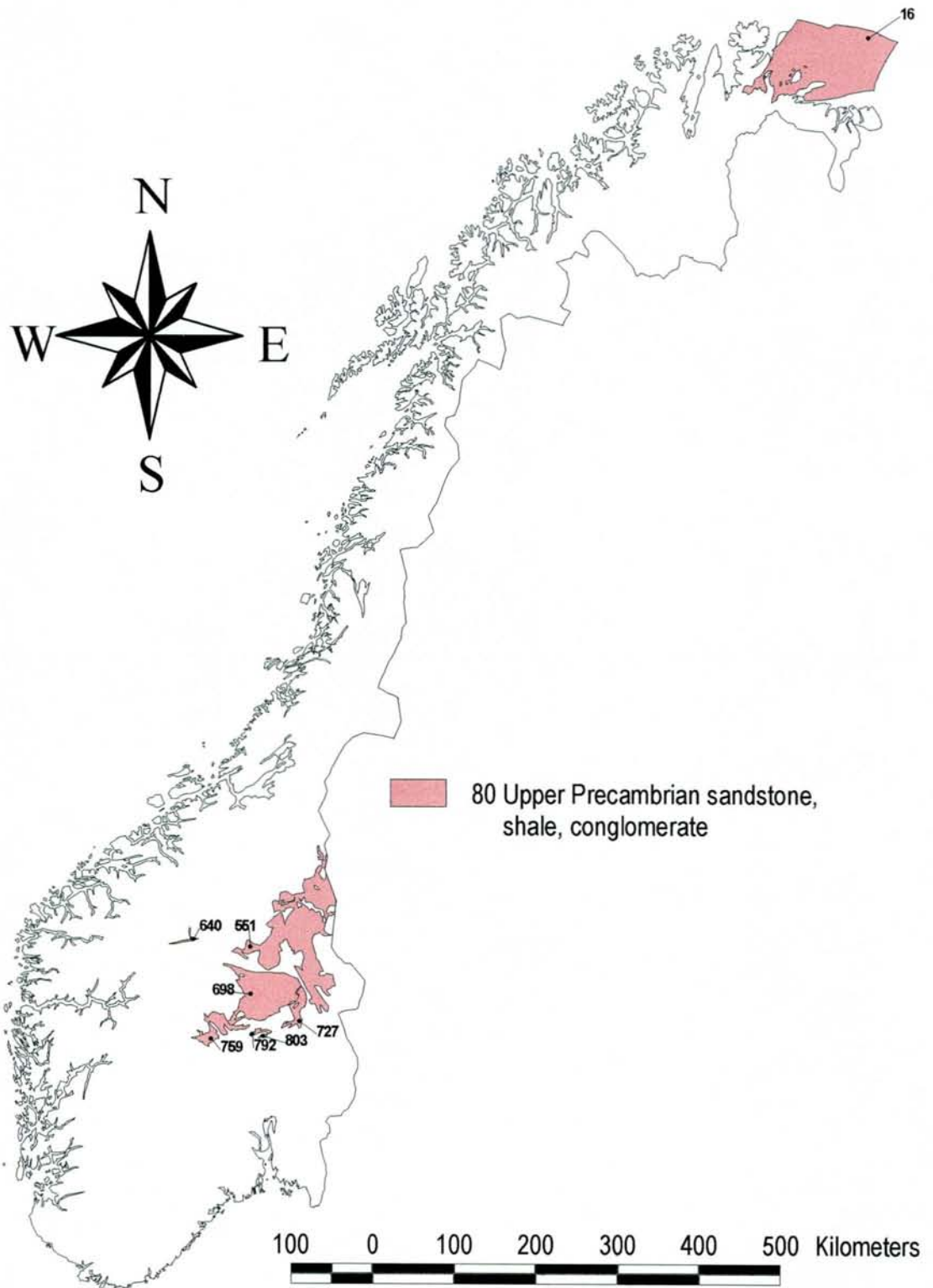


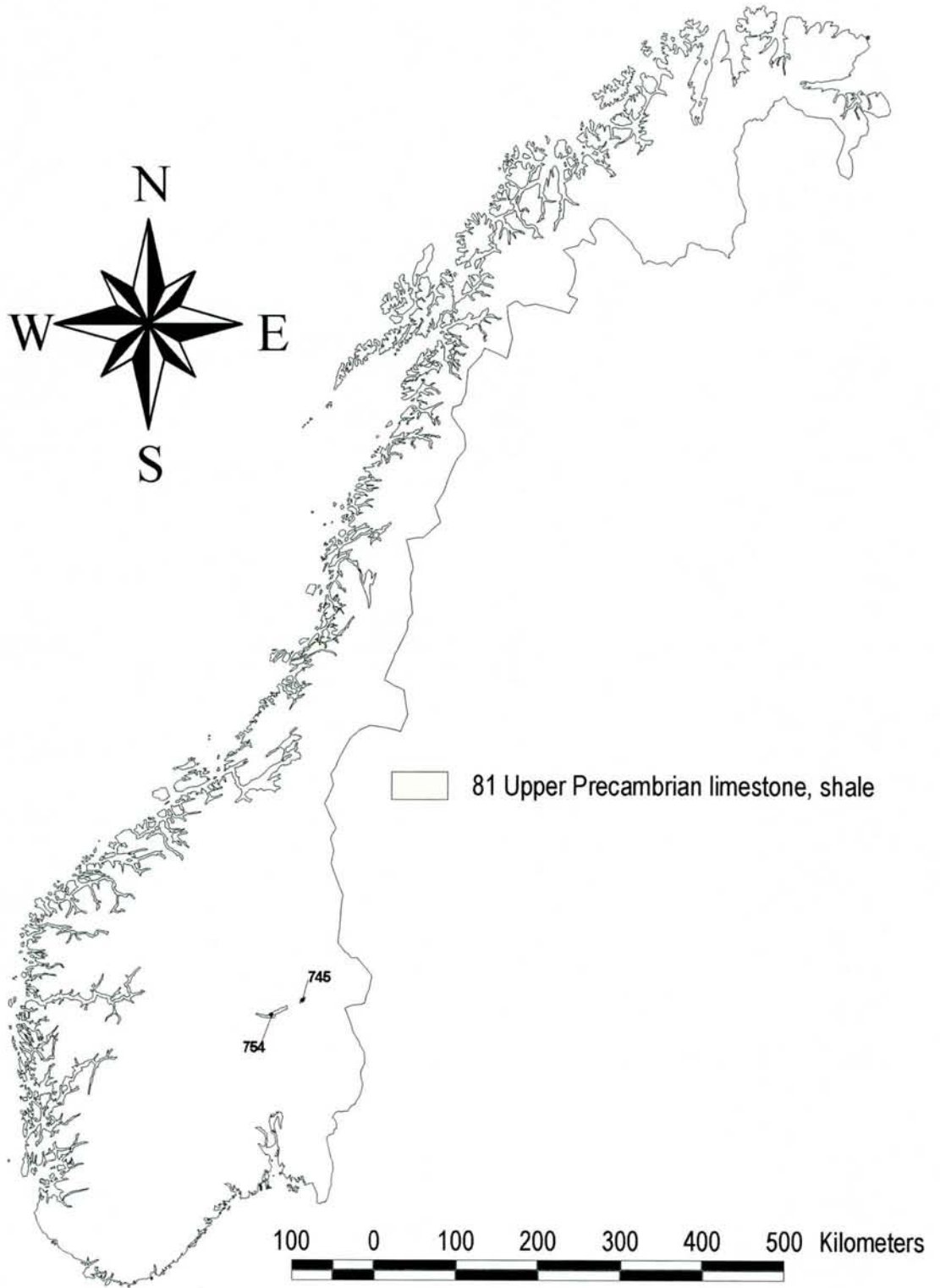


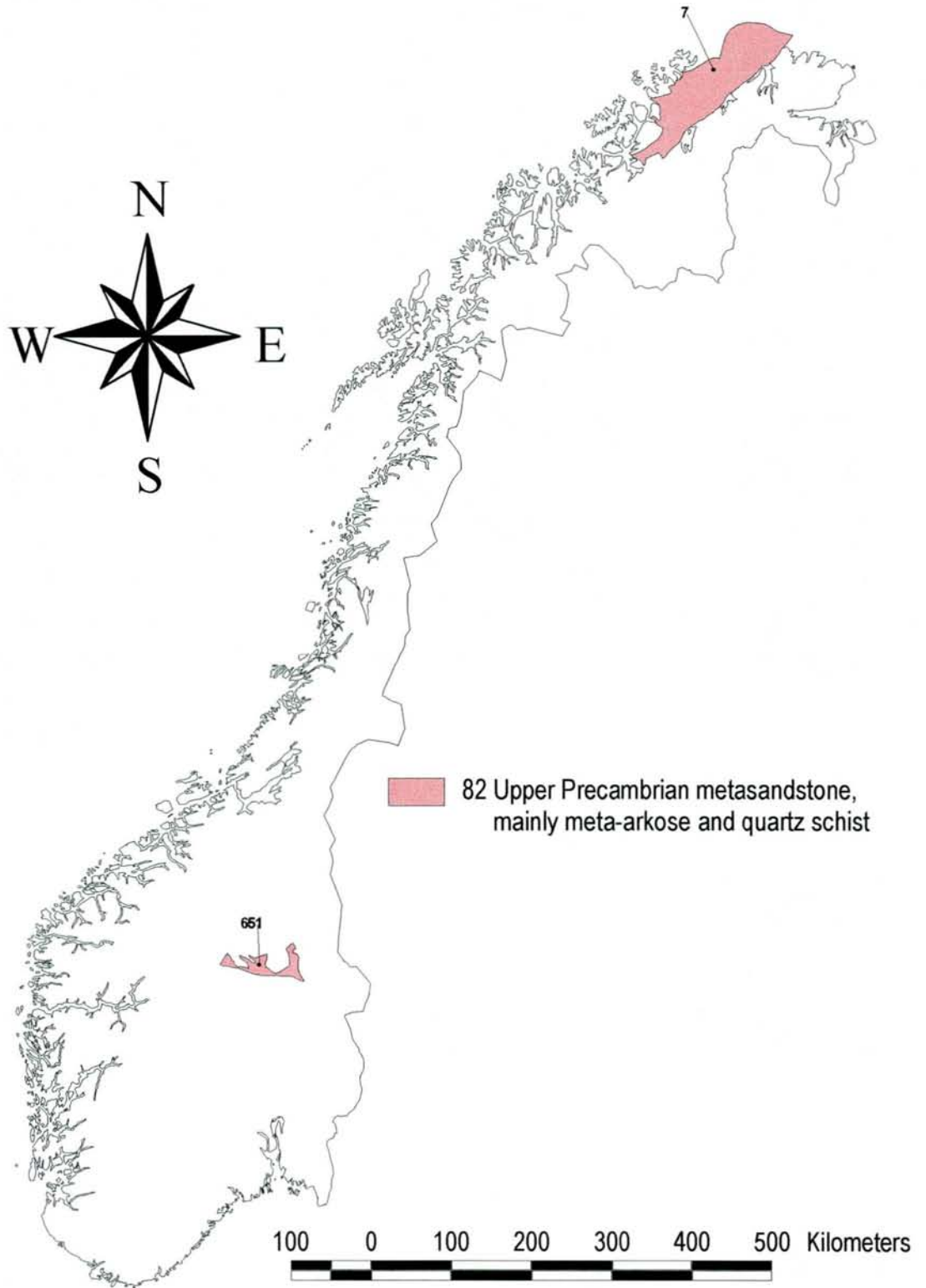


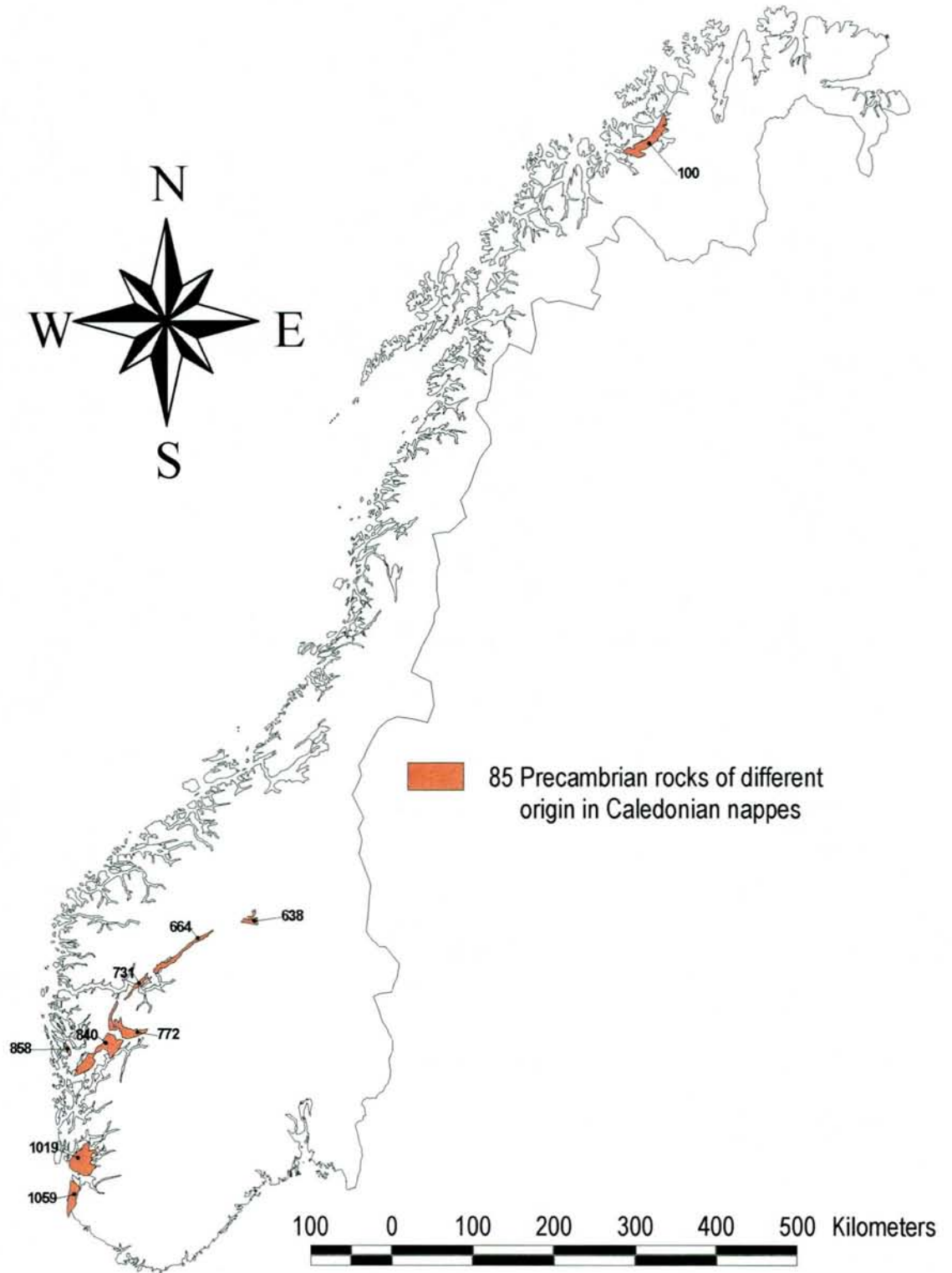


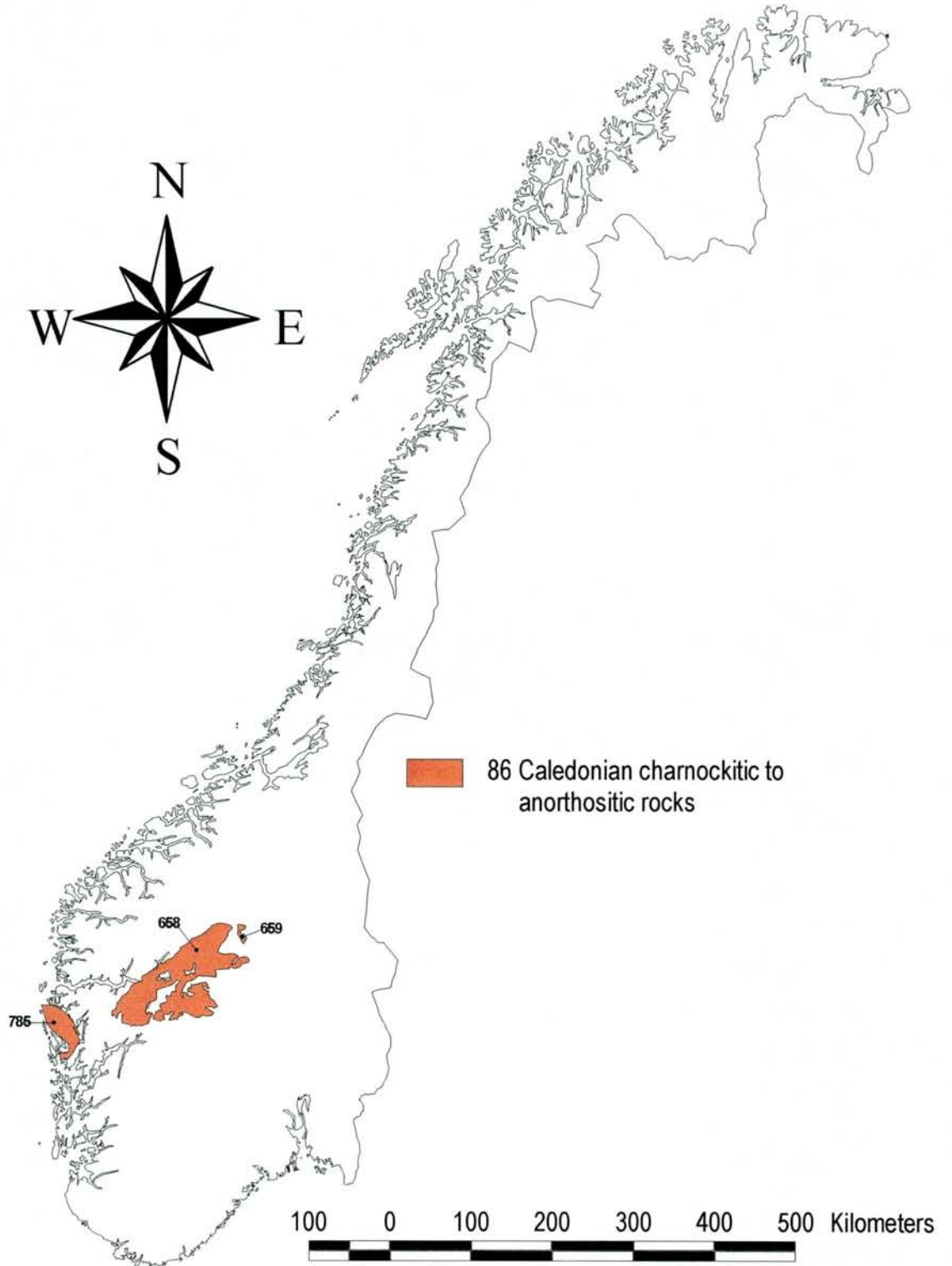


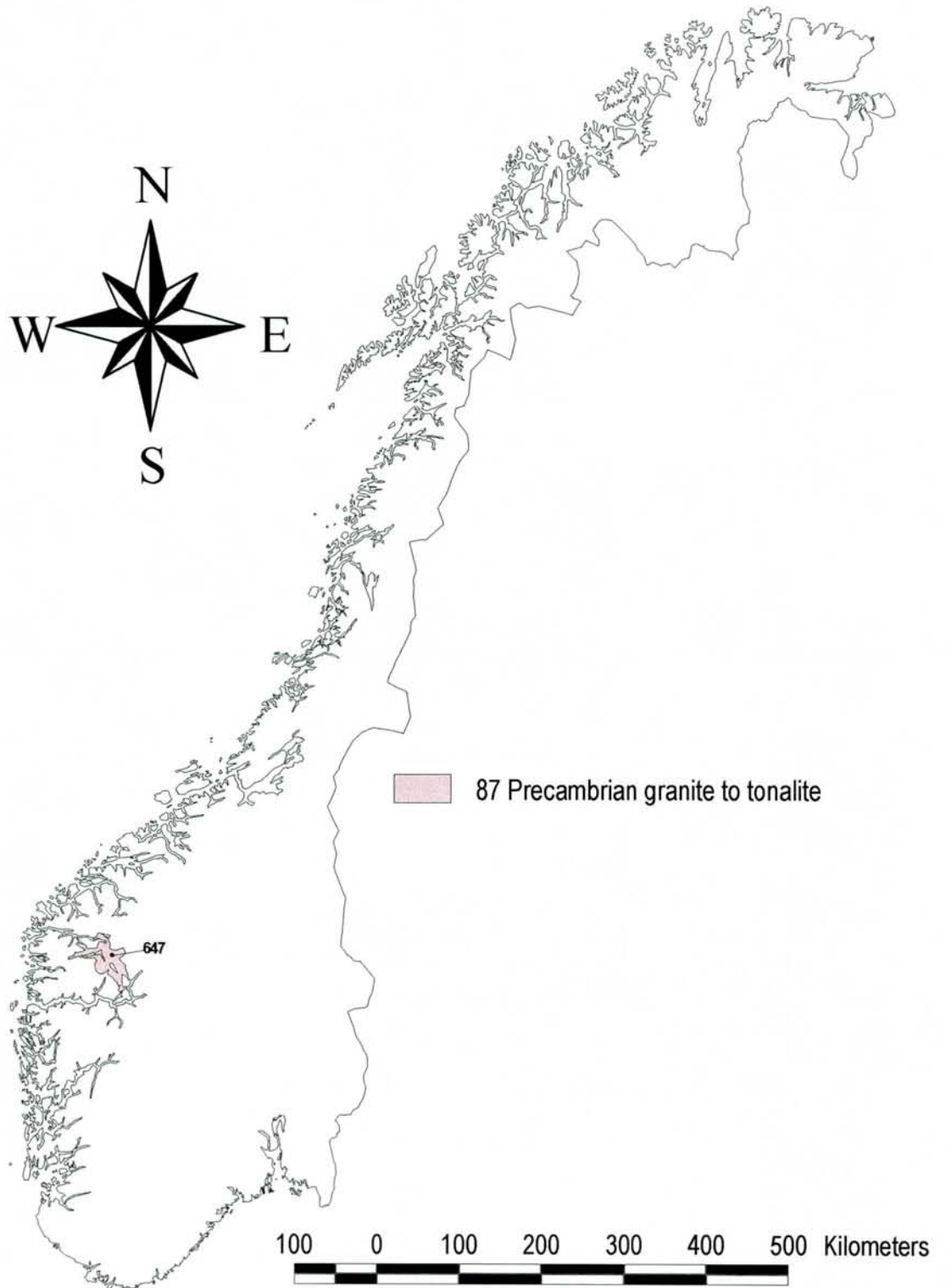


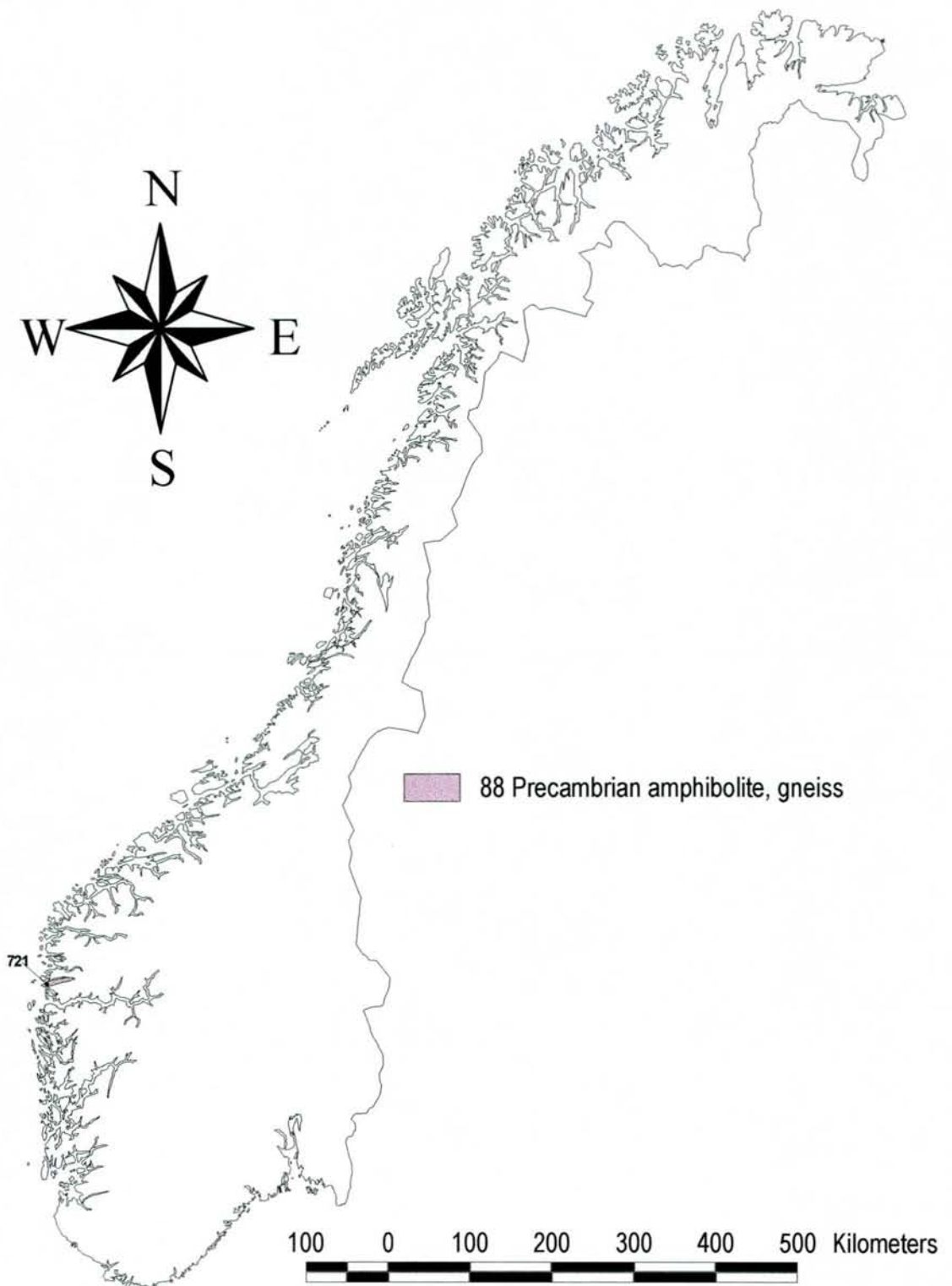


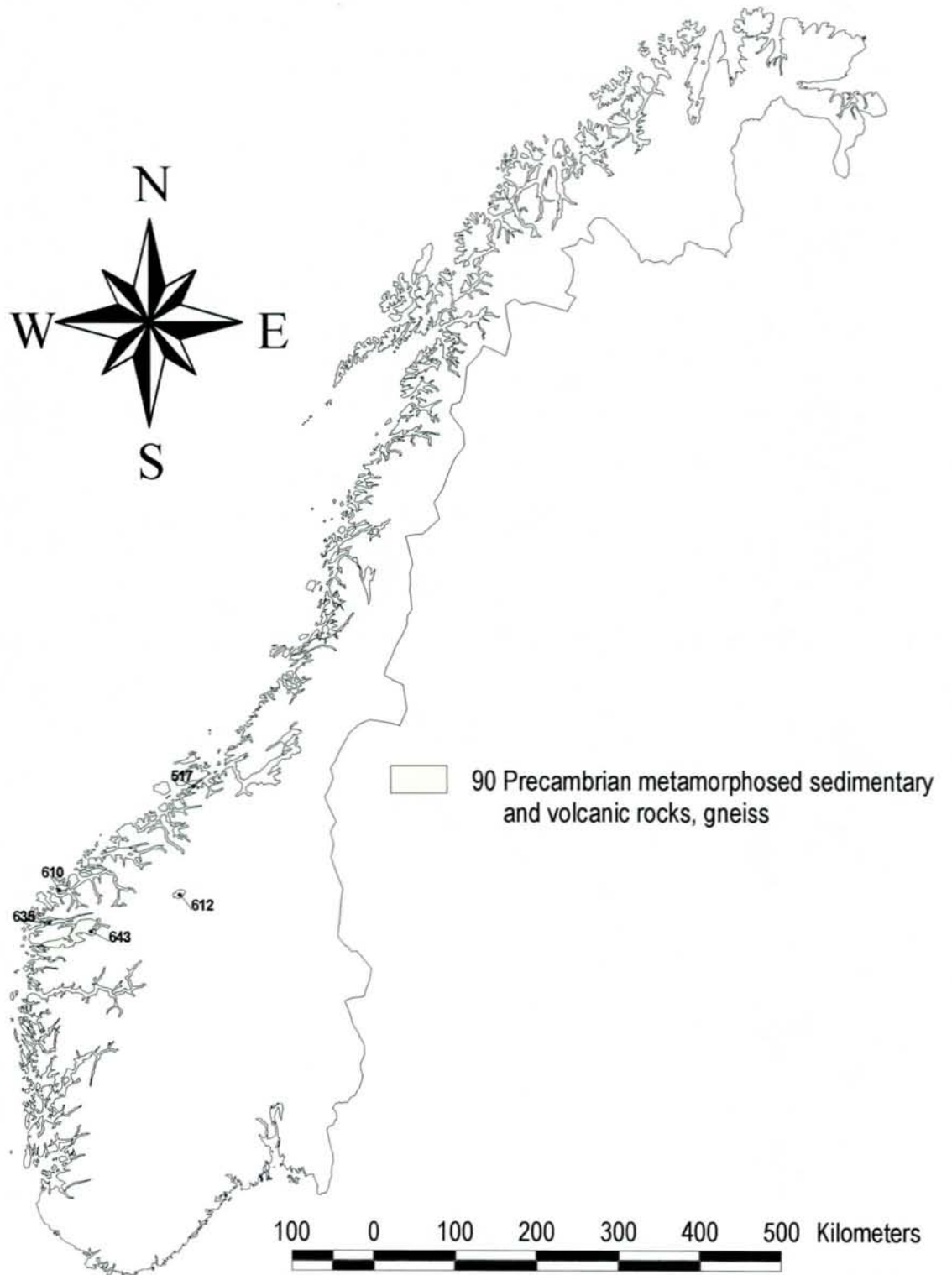


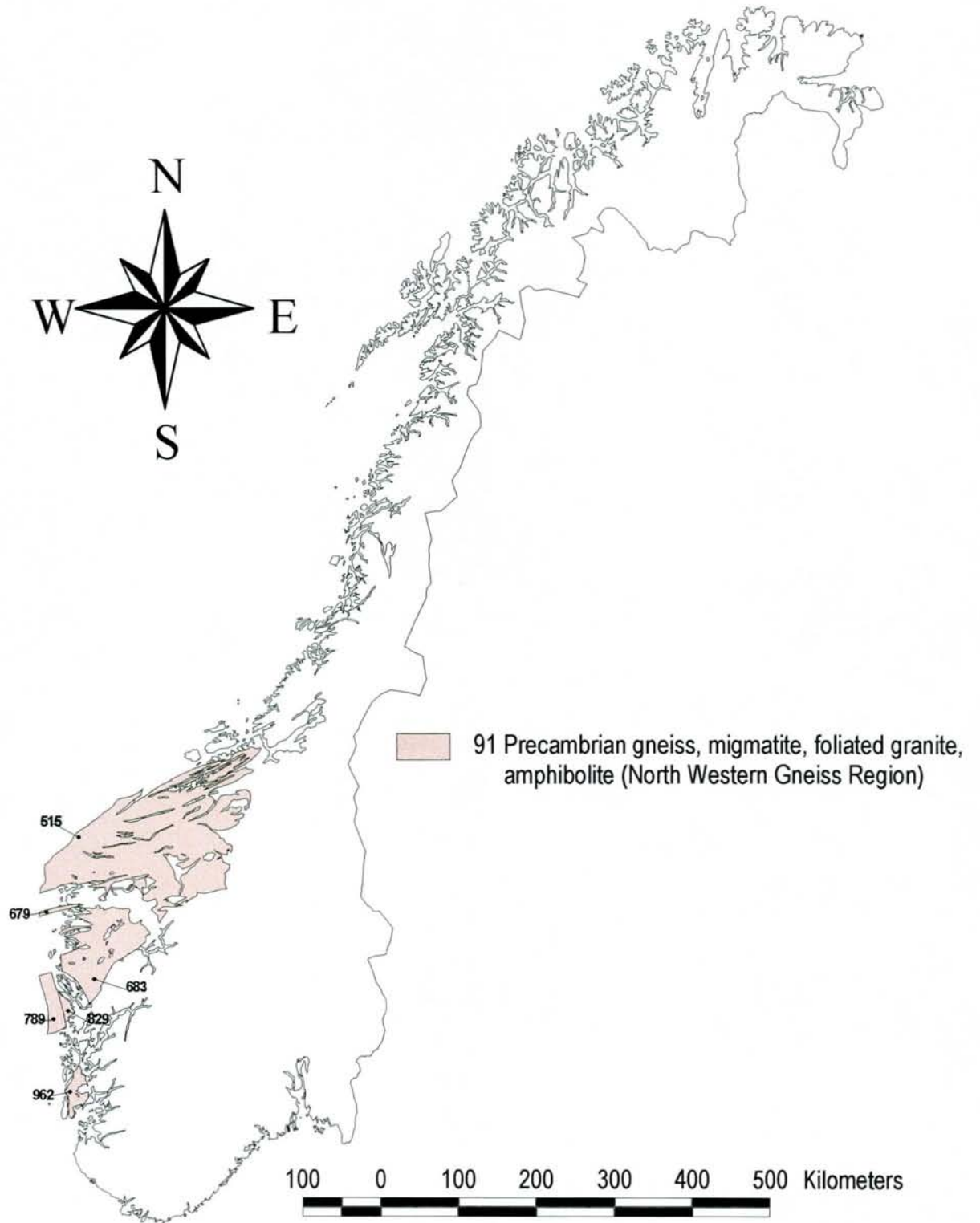


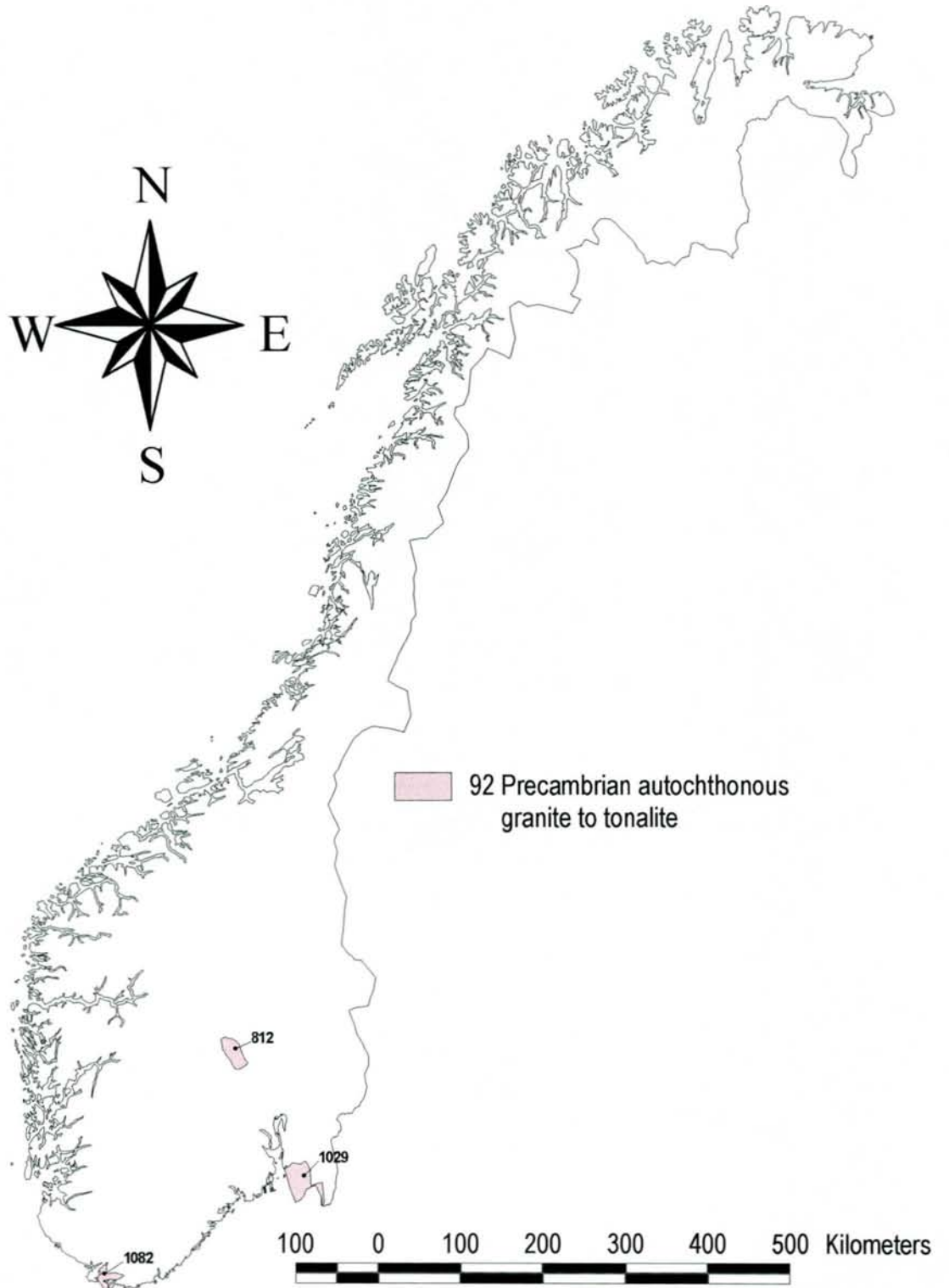


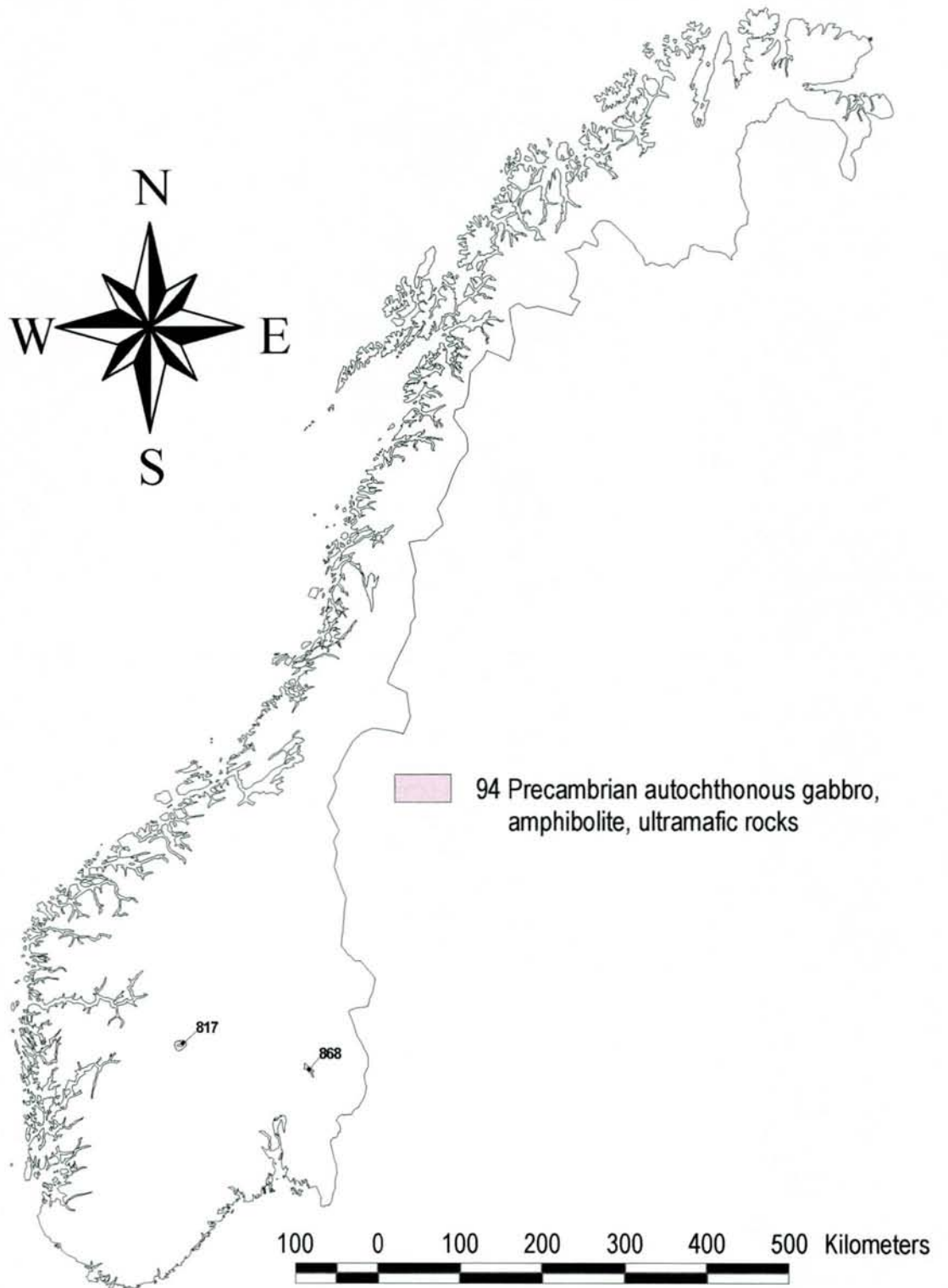


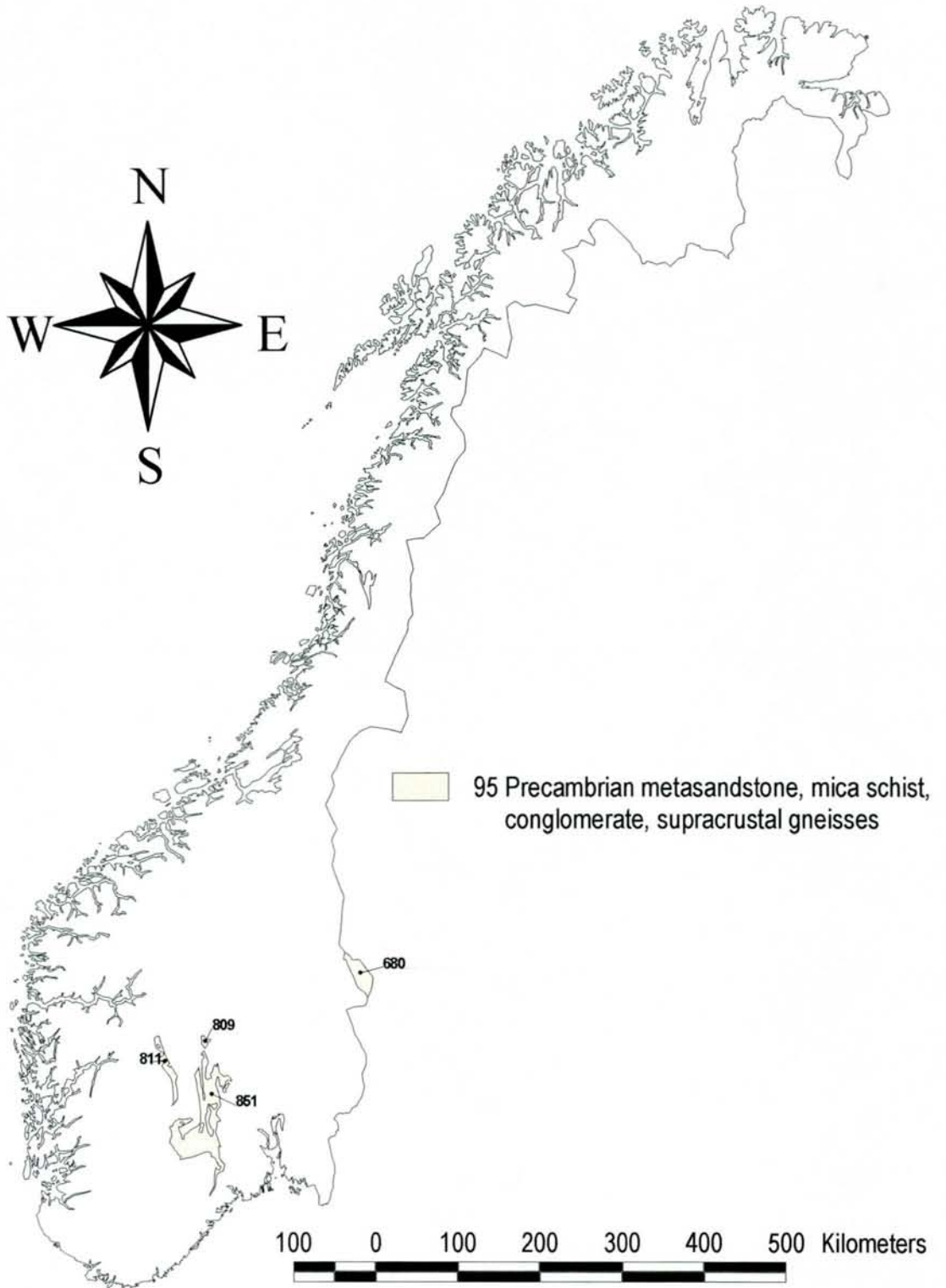


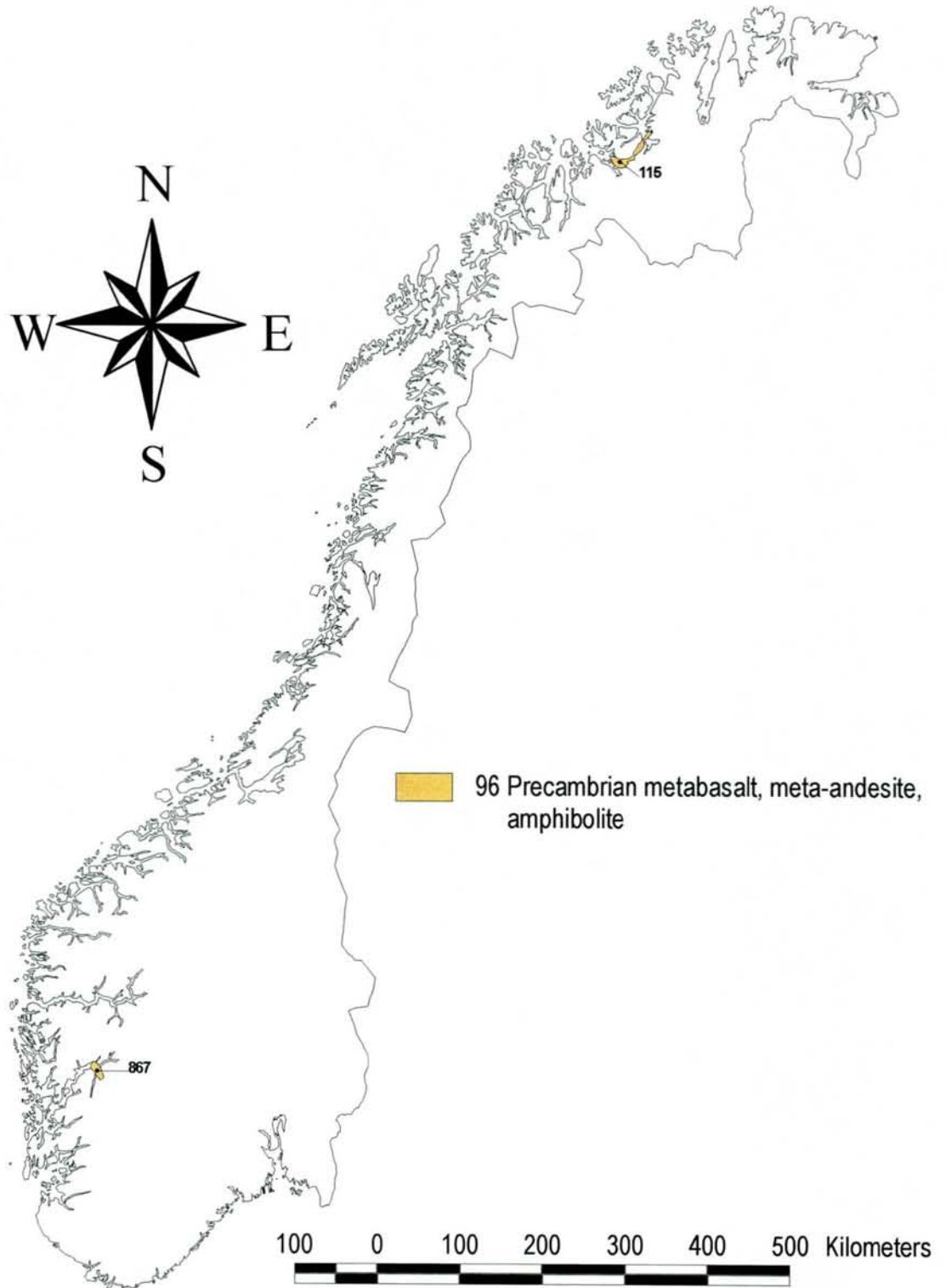


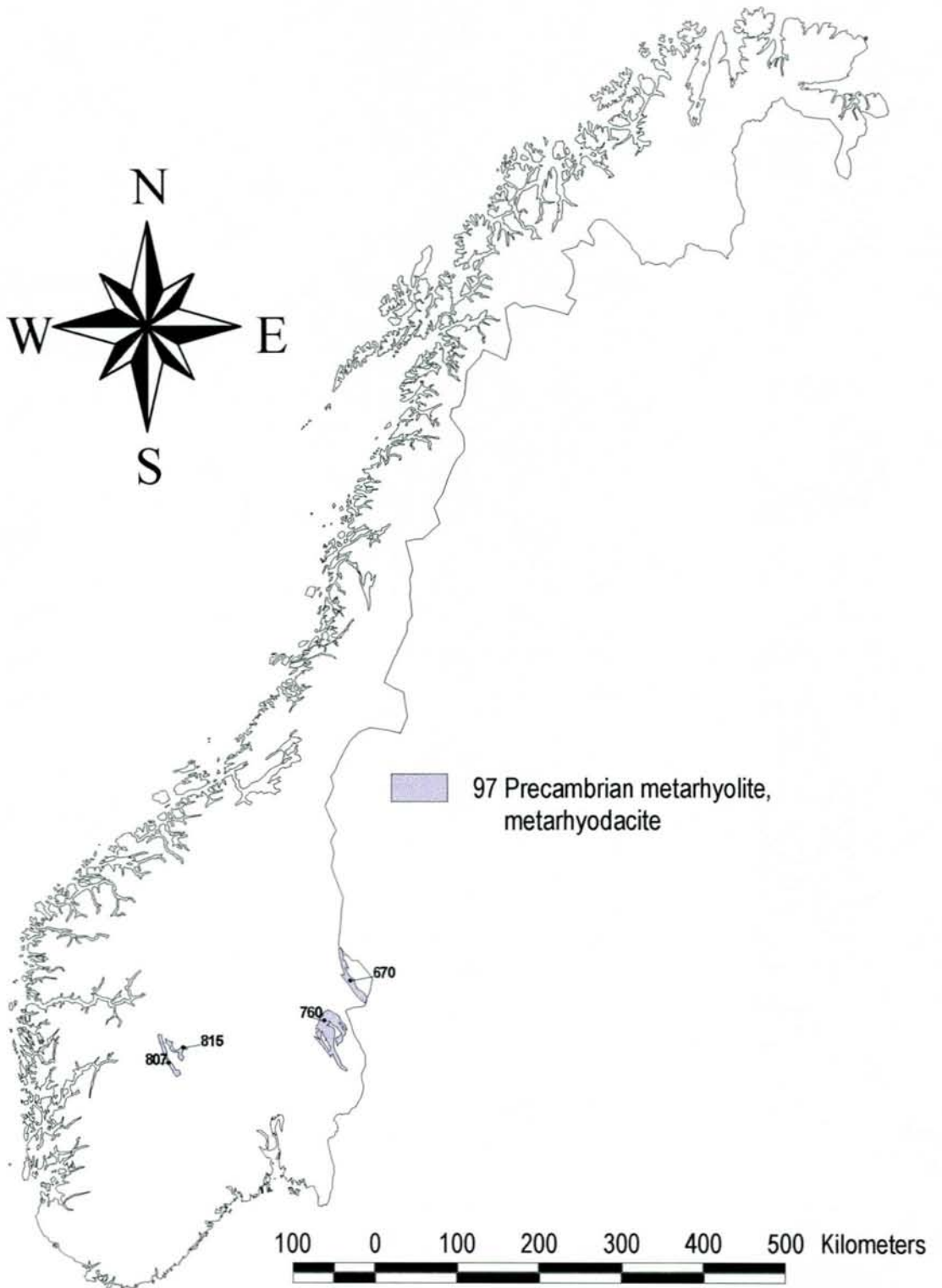


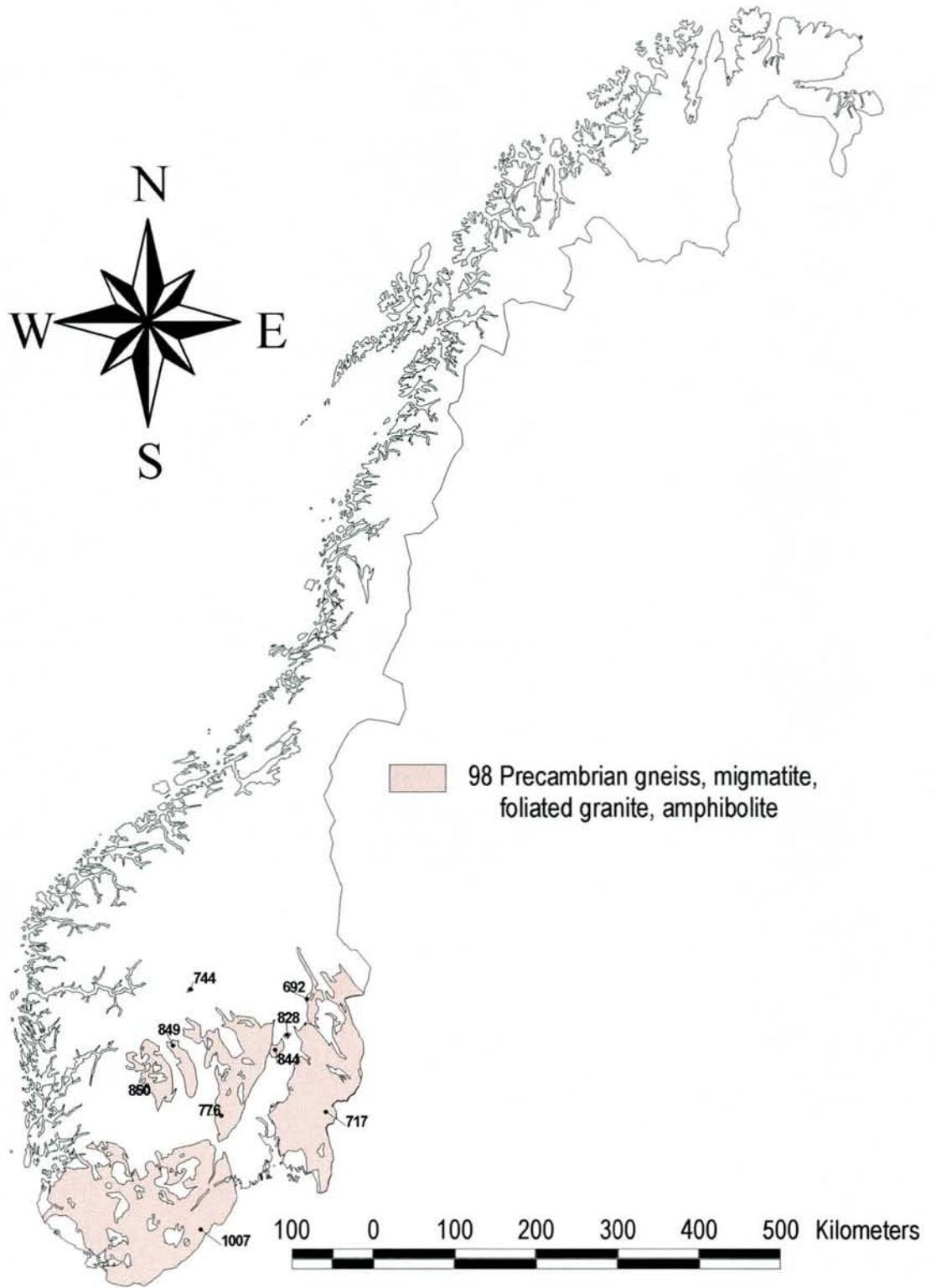






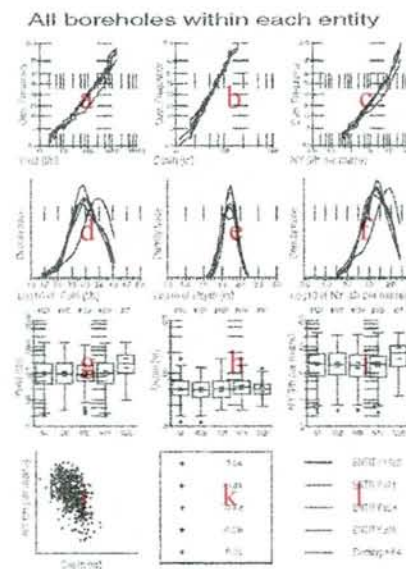






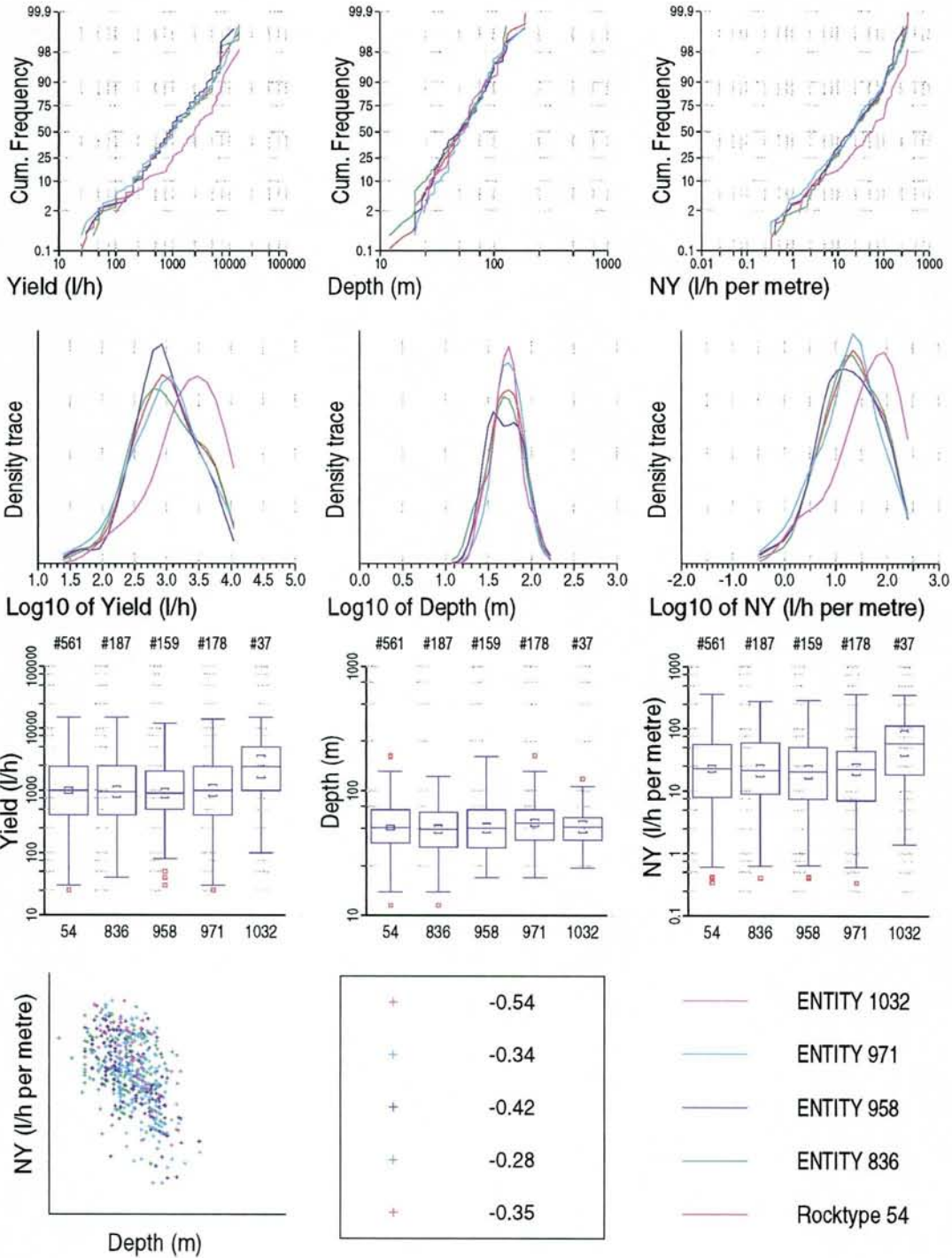
Appendix B

Graphical presentation of all boreholes within each entity

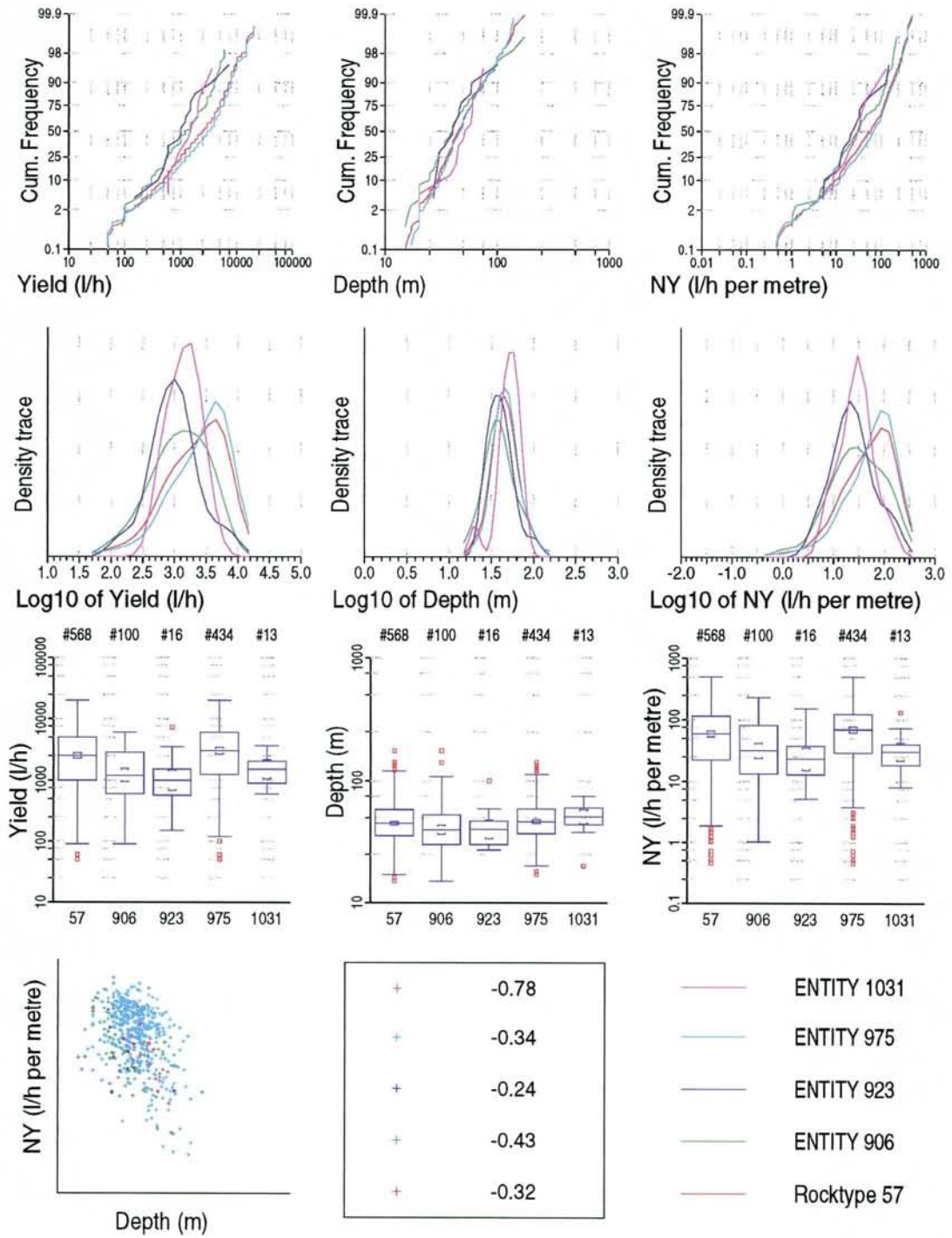


- a: CDF diagram; yield (L/h)
- b: CDF diagram; depth (m)
- c: CDF diagram; normalised yield (L/h per metre)
- d: Density trace diagram; yield (L/h)
- e: Density trace diagram; depth (m)
- f: Density trace diagram; normalised yield (L/h per metre)
- g: Boxplot diagram; yield (L/h)
- h: Boxplot diagram; depth (m)
- i: Boxplot diagram; normalised yield (L/h per metre)
- j: XY-diagram; depth (m) and normalised yield (L/h per metre)
- k: Pearson's r; depth (m) and normalised yield (L/h per metre)
- l: Legend

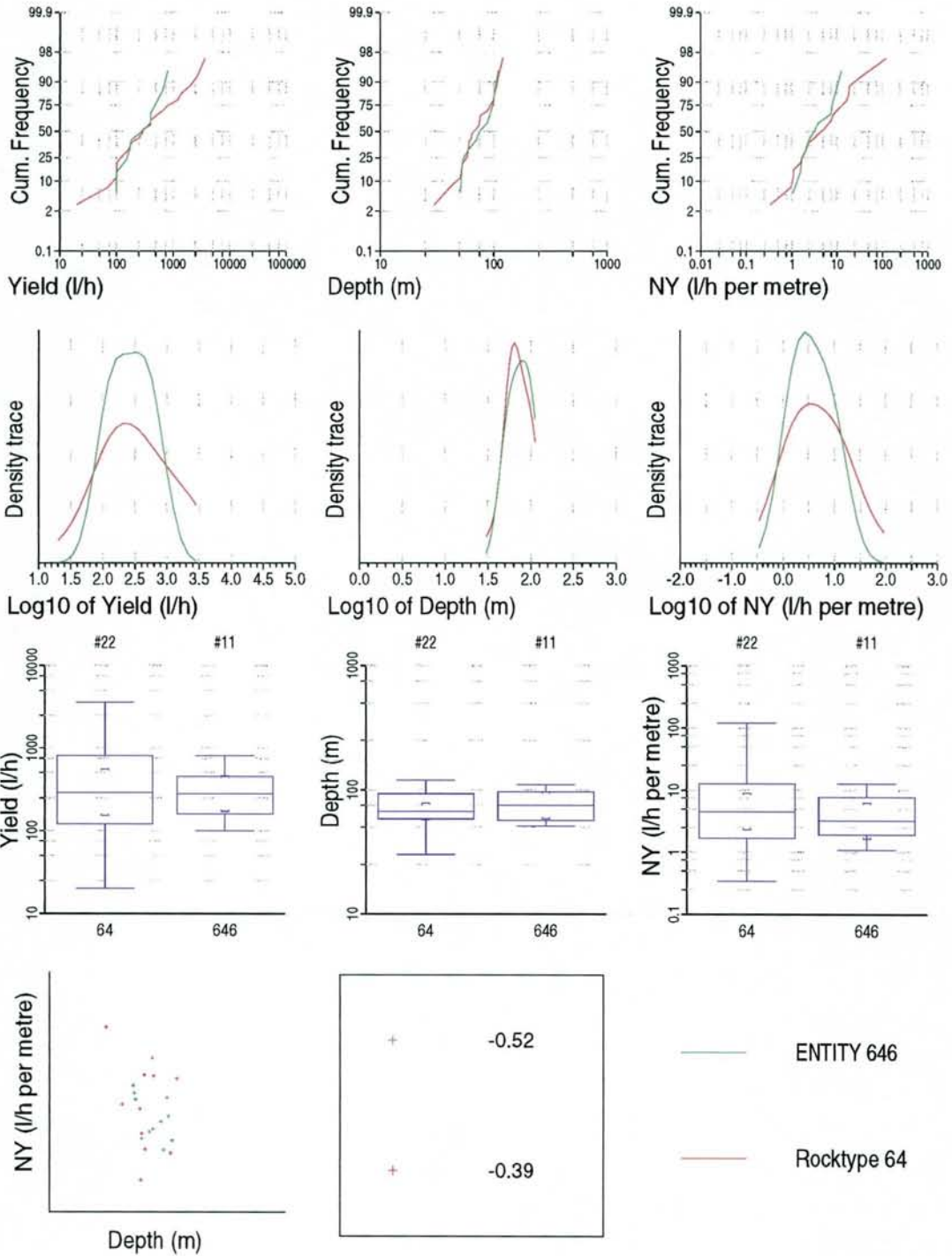
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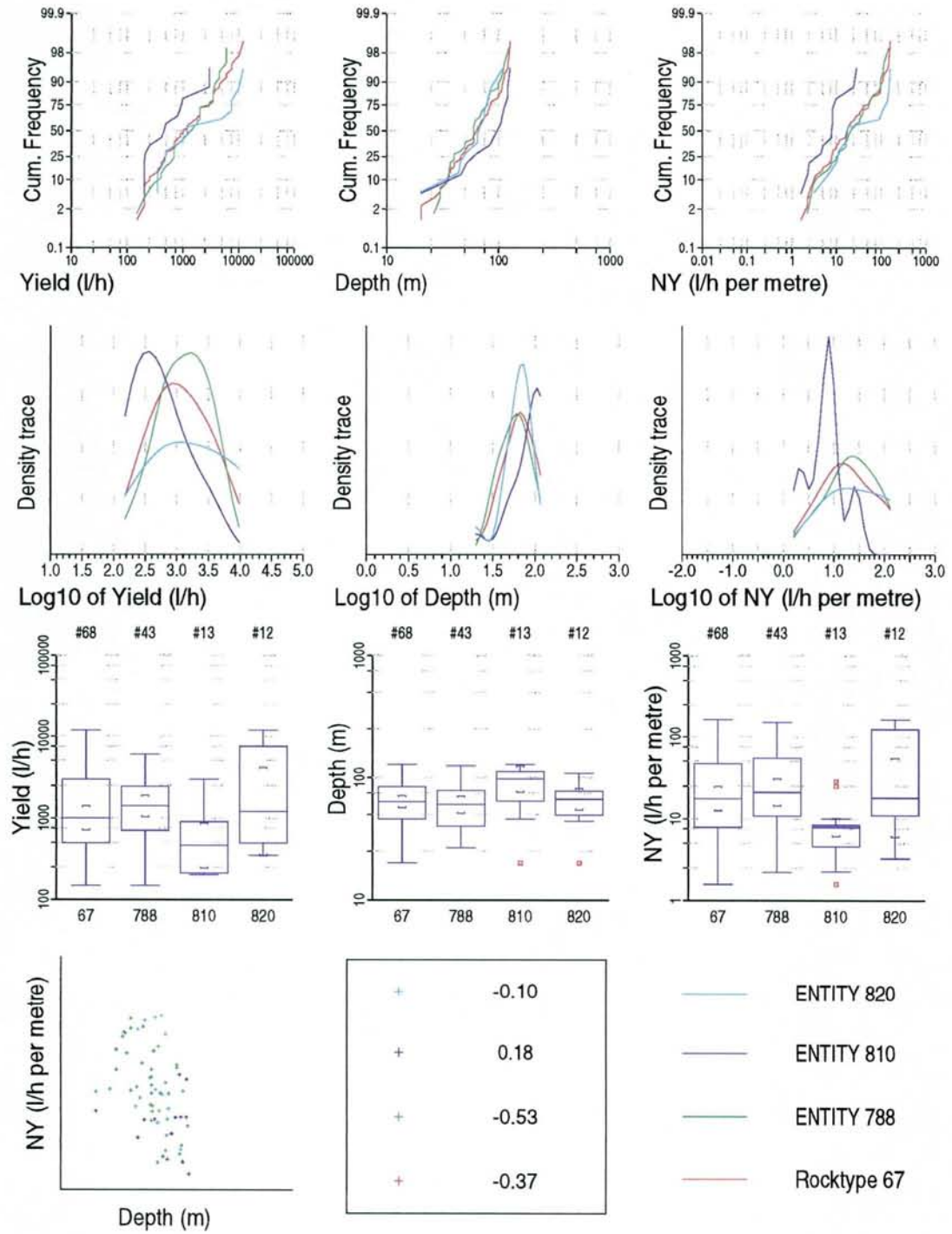
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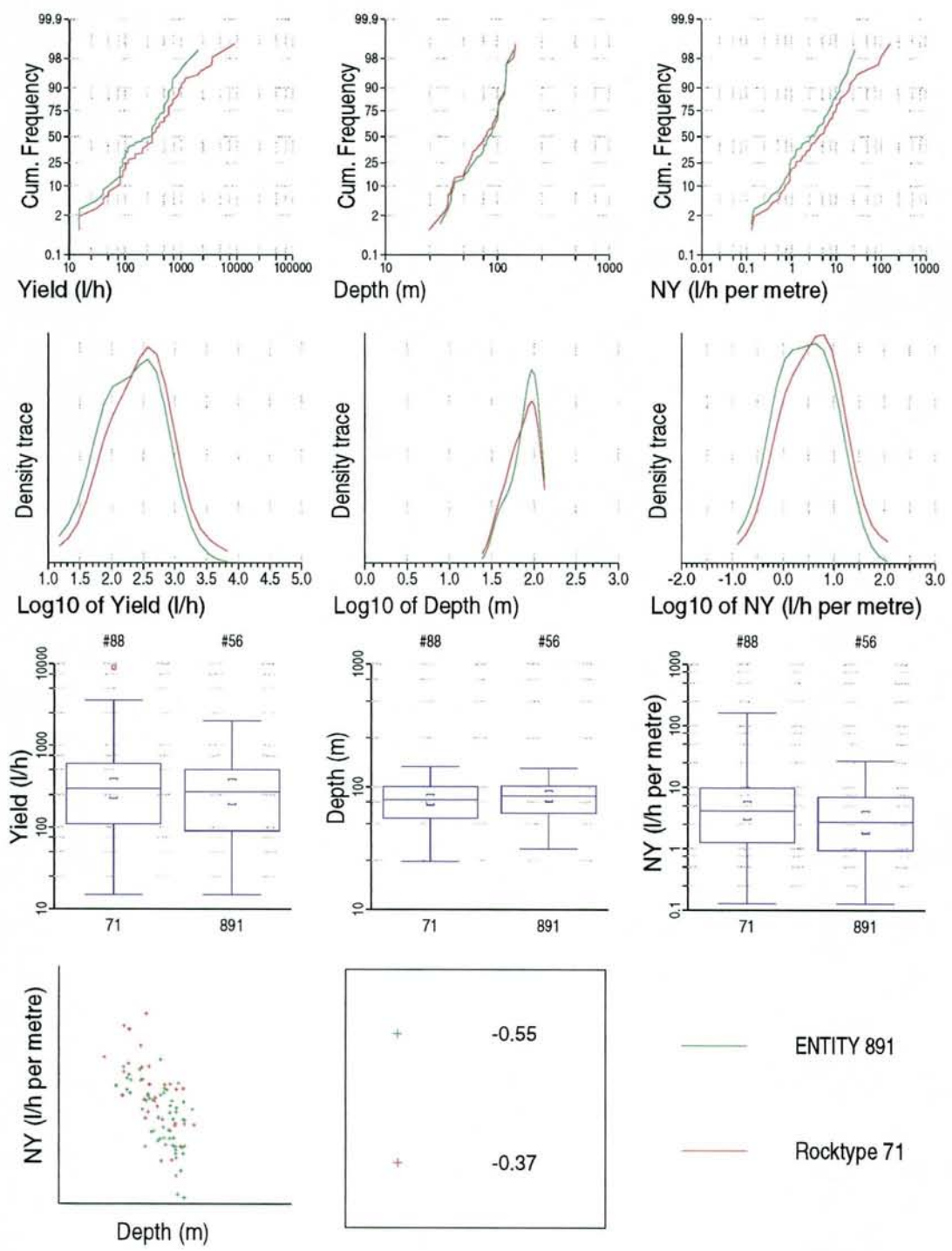
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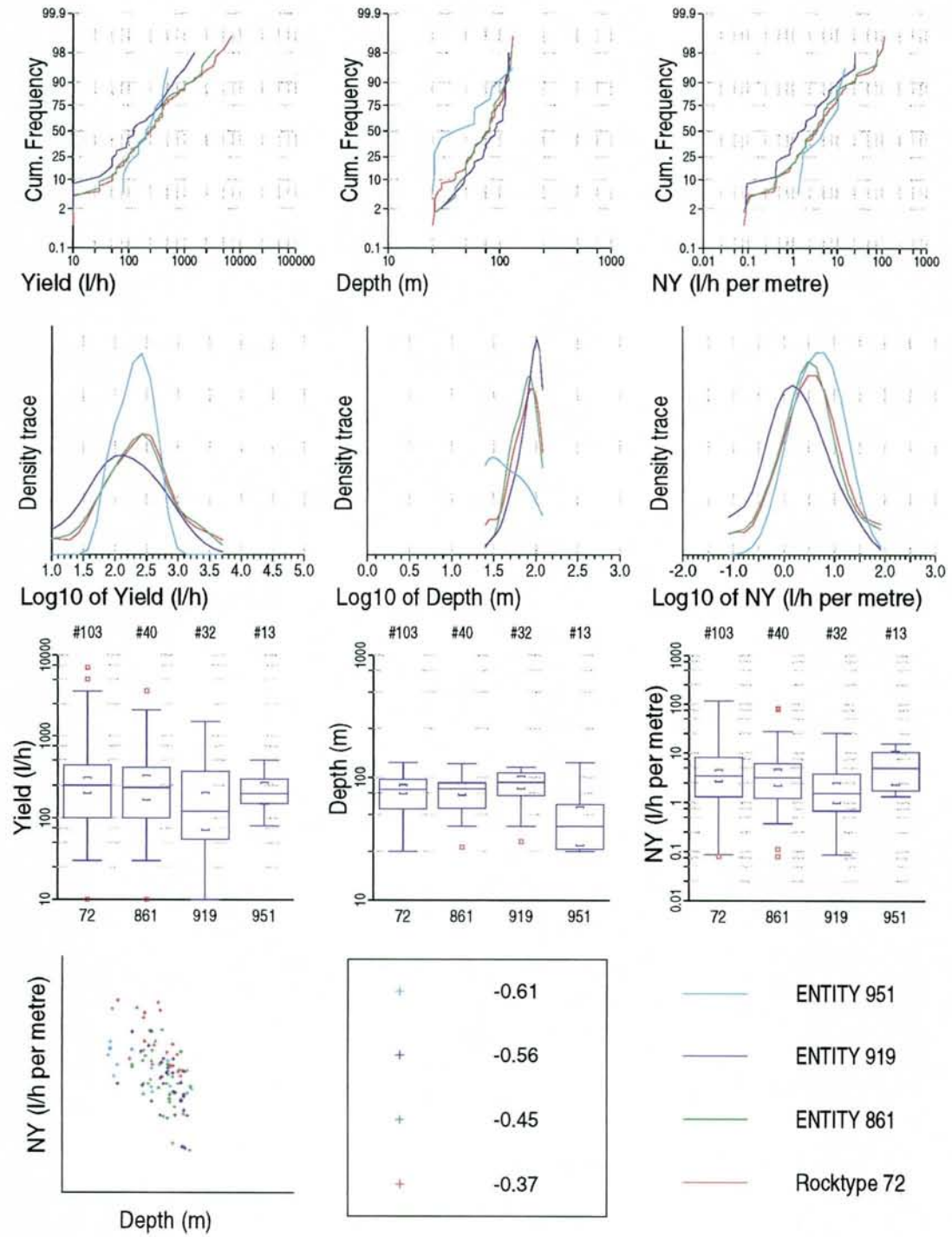
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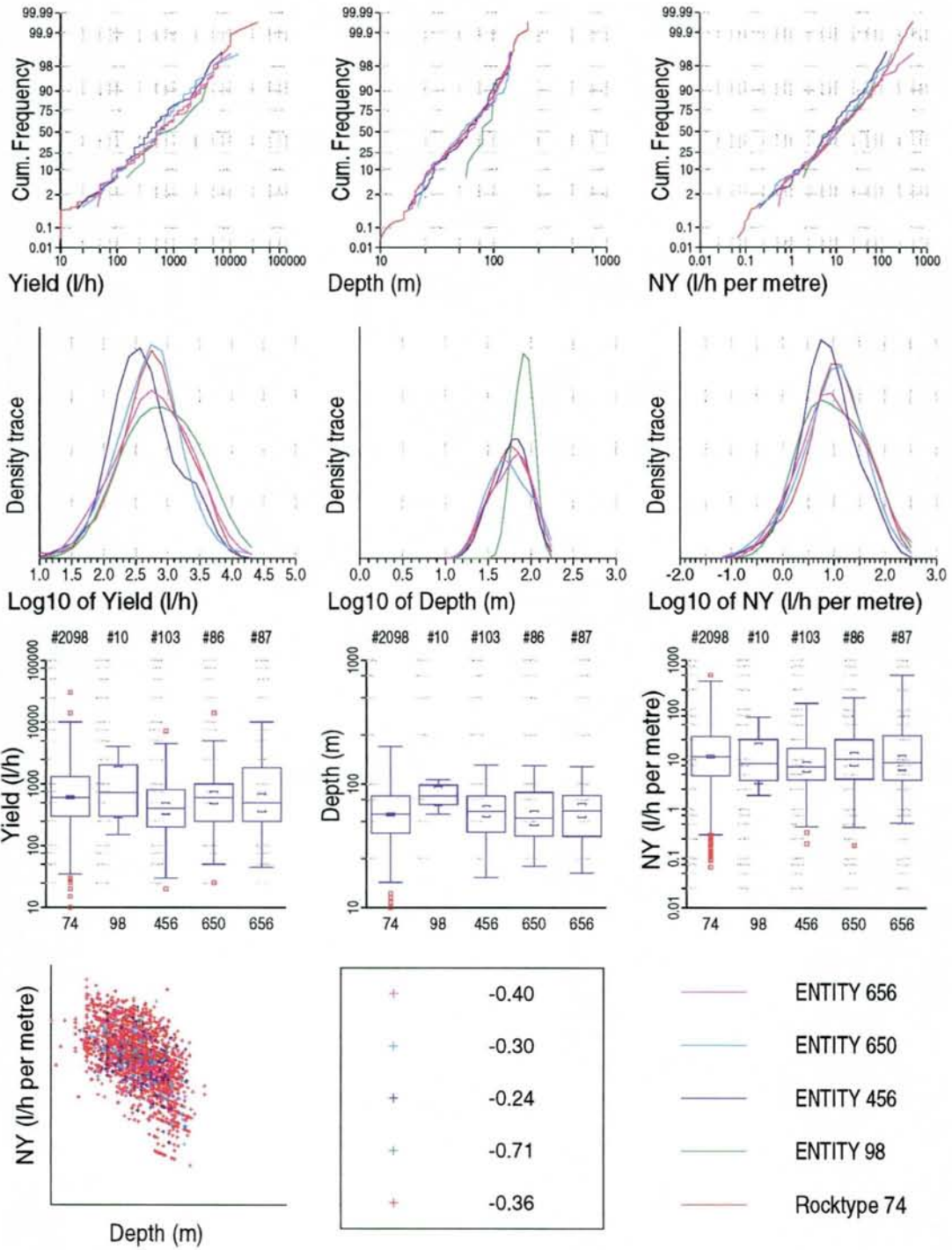
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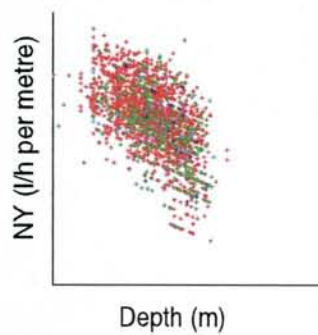
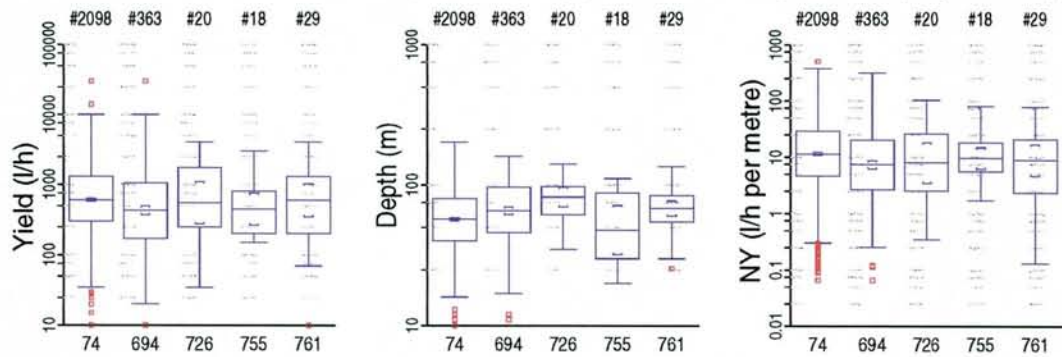
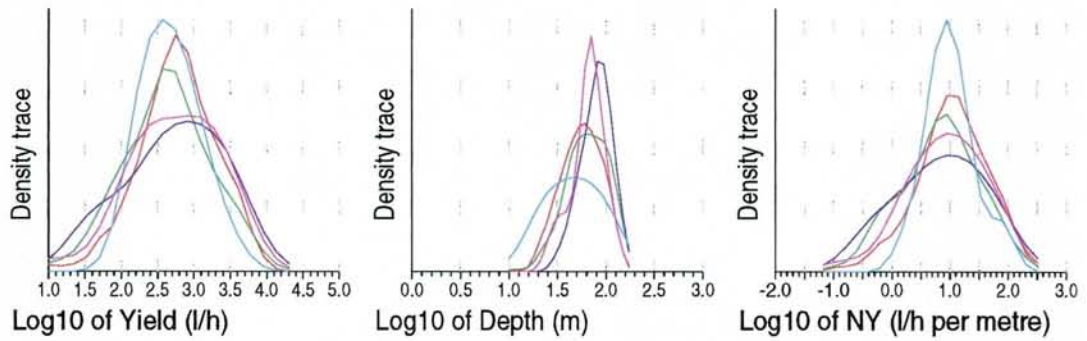
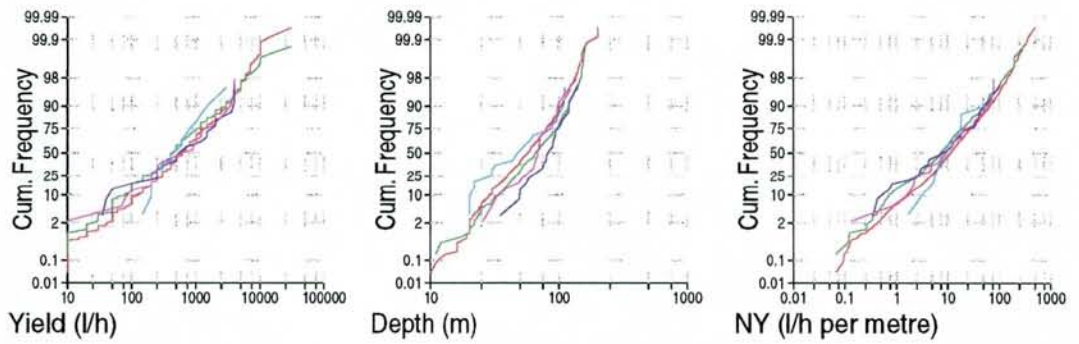
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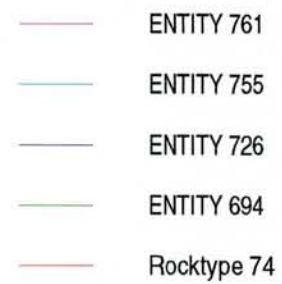
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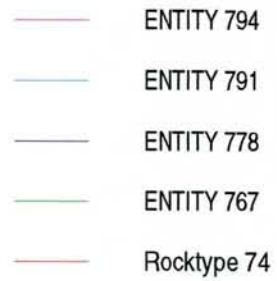
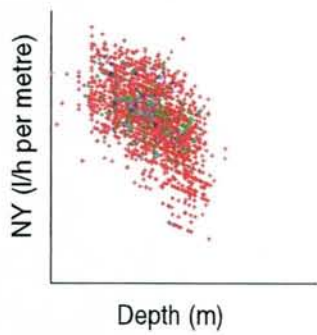
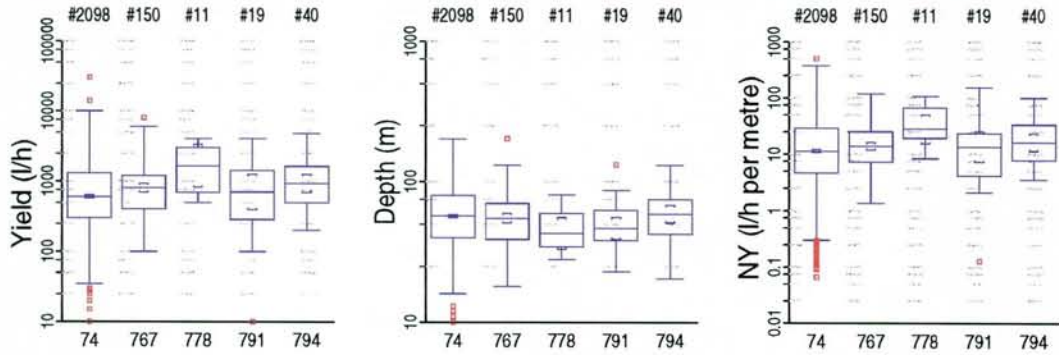
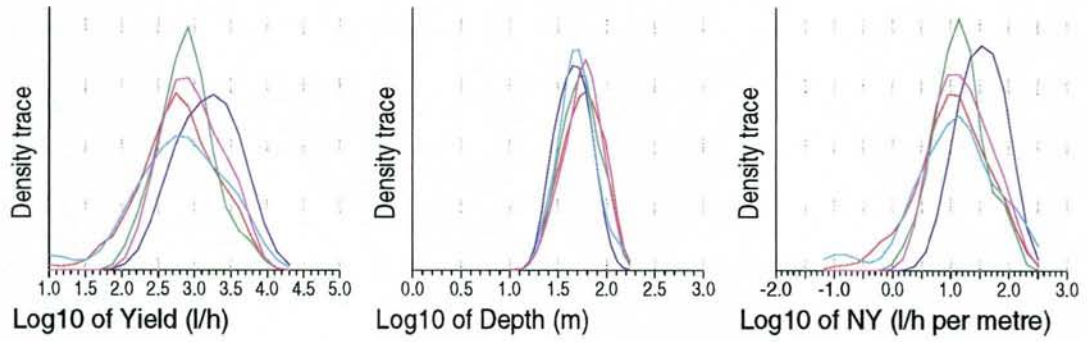
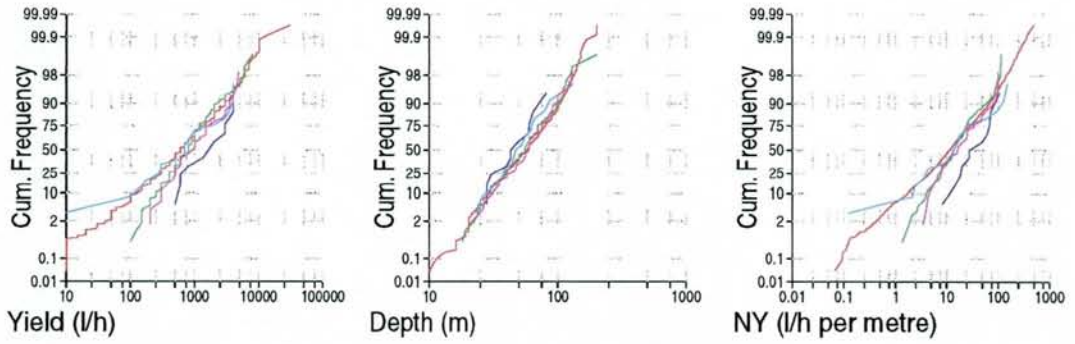
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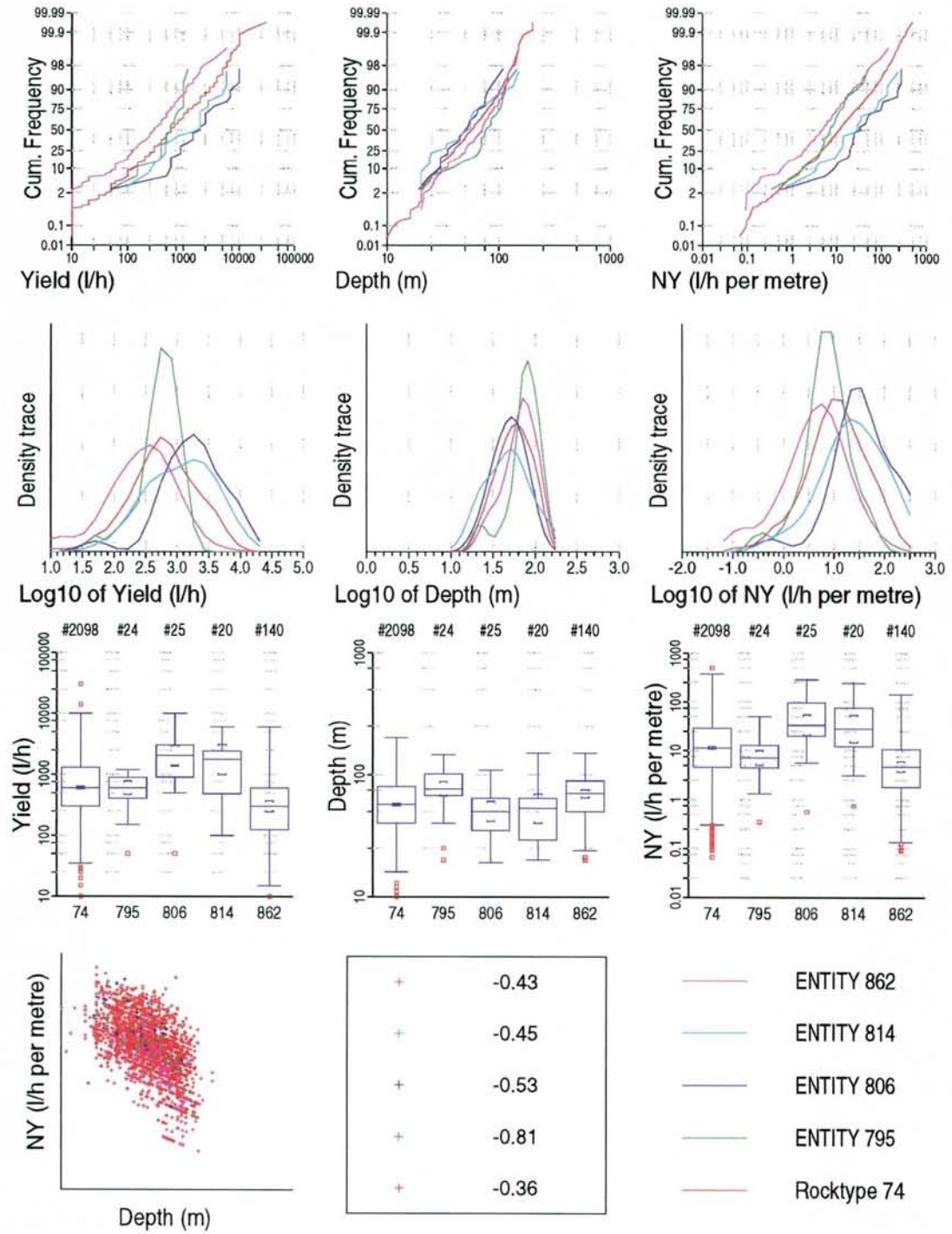
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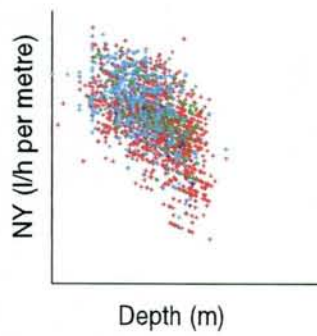
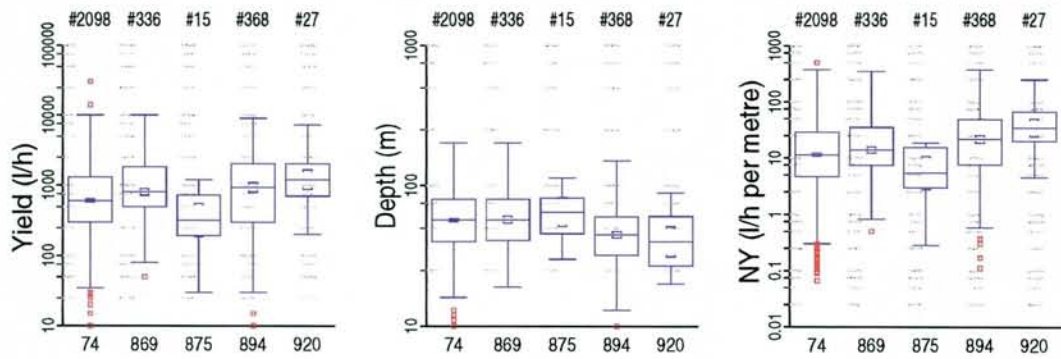
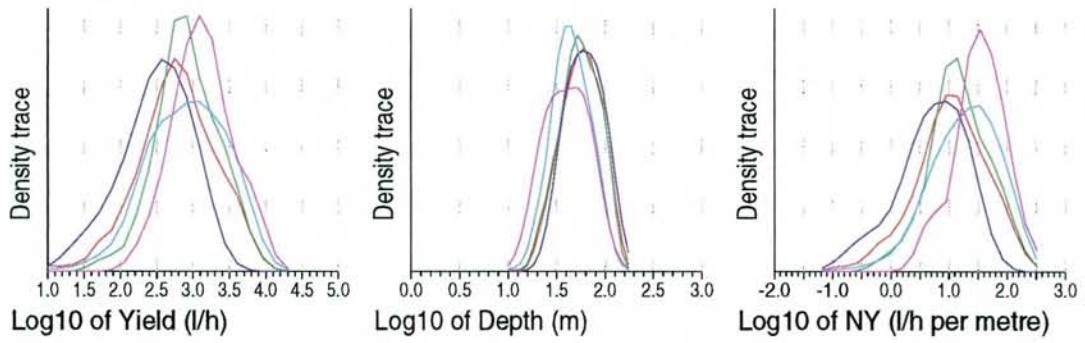
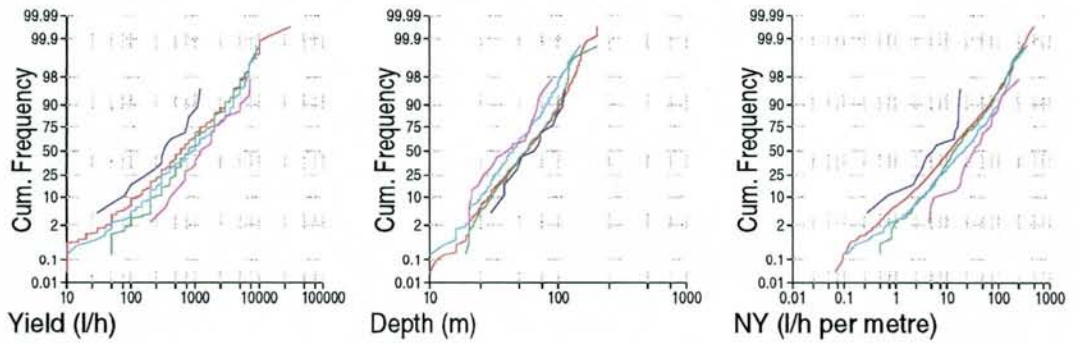
All boreholes within each entity



All boreholes within each entity



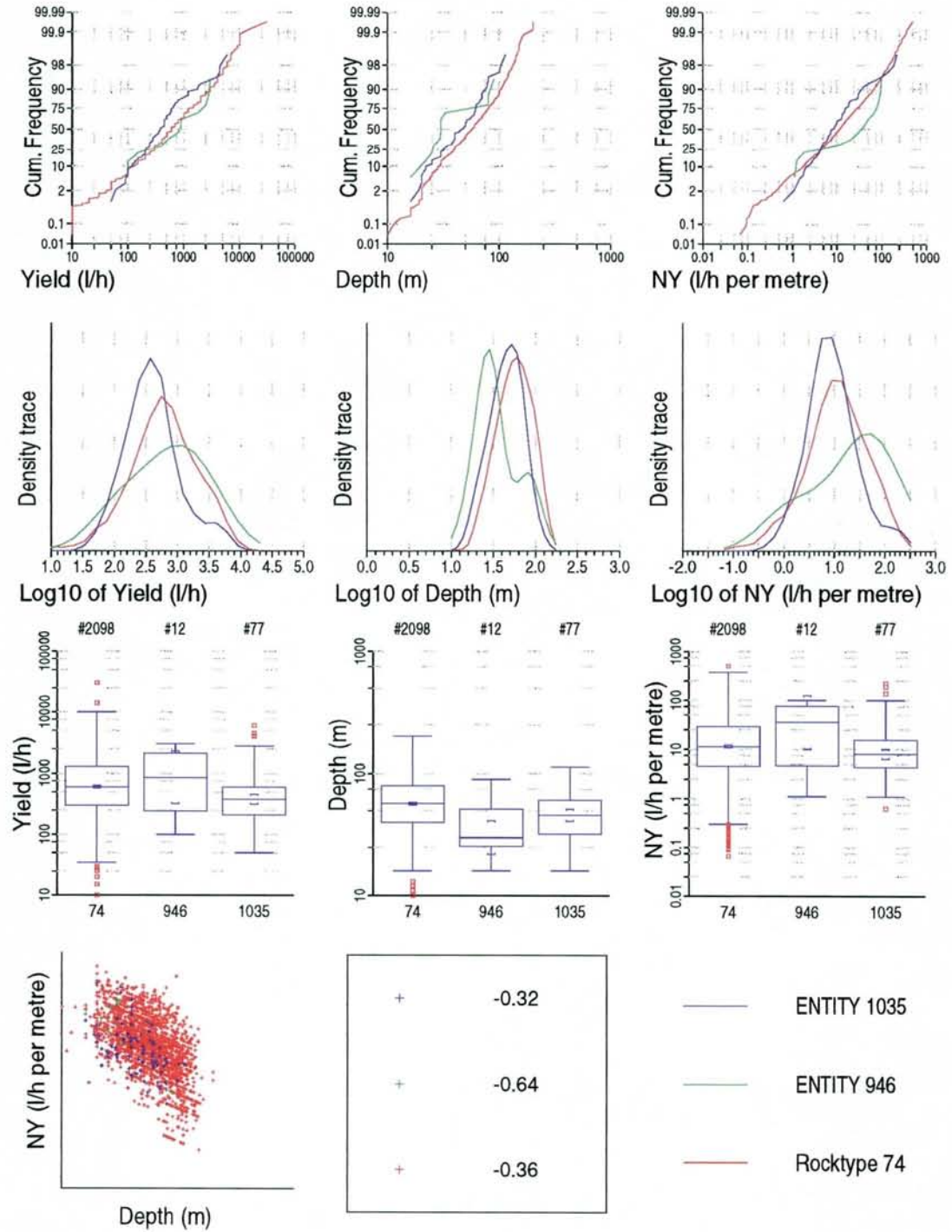
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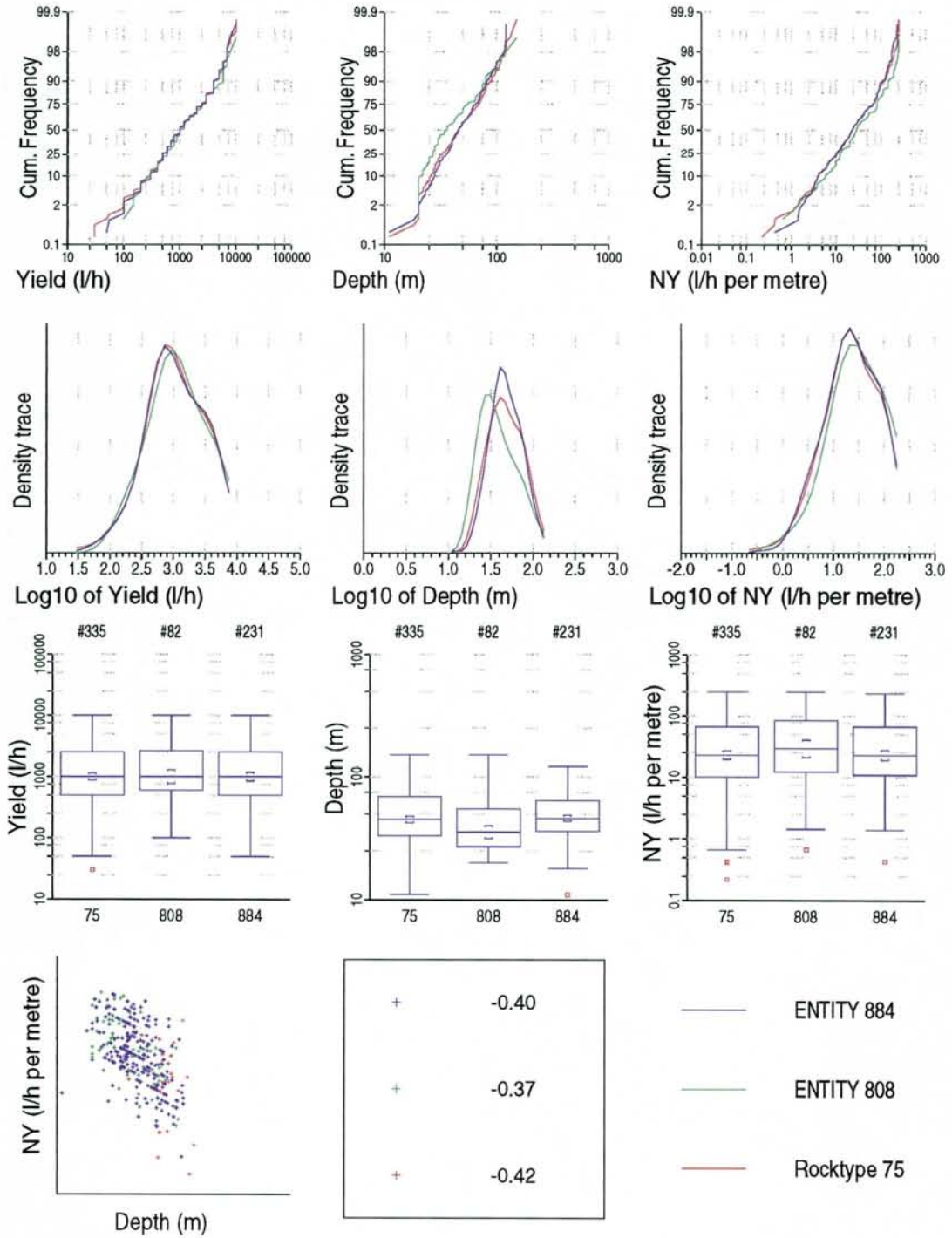
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- Rocktype 74

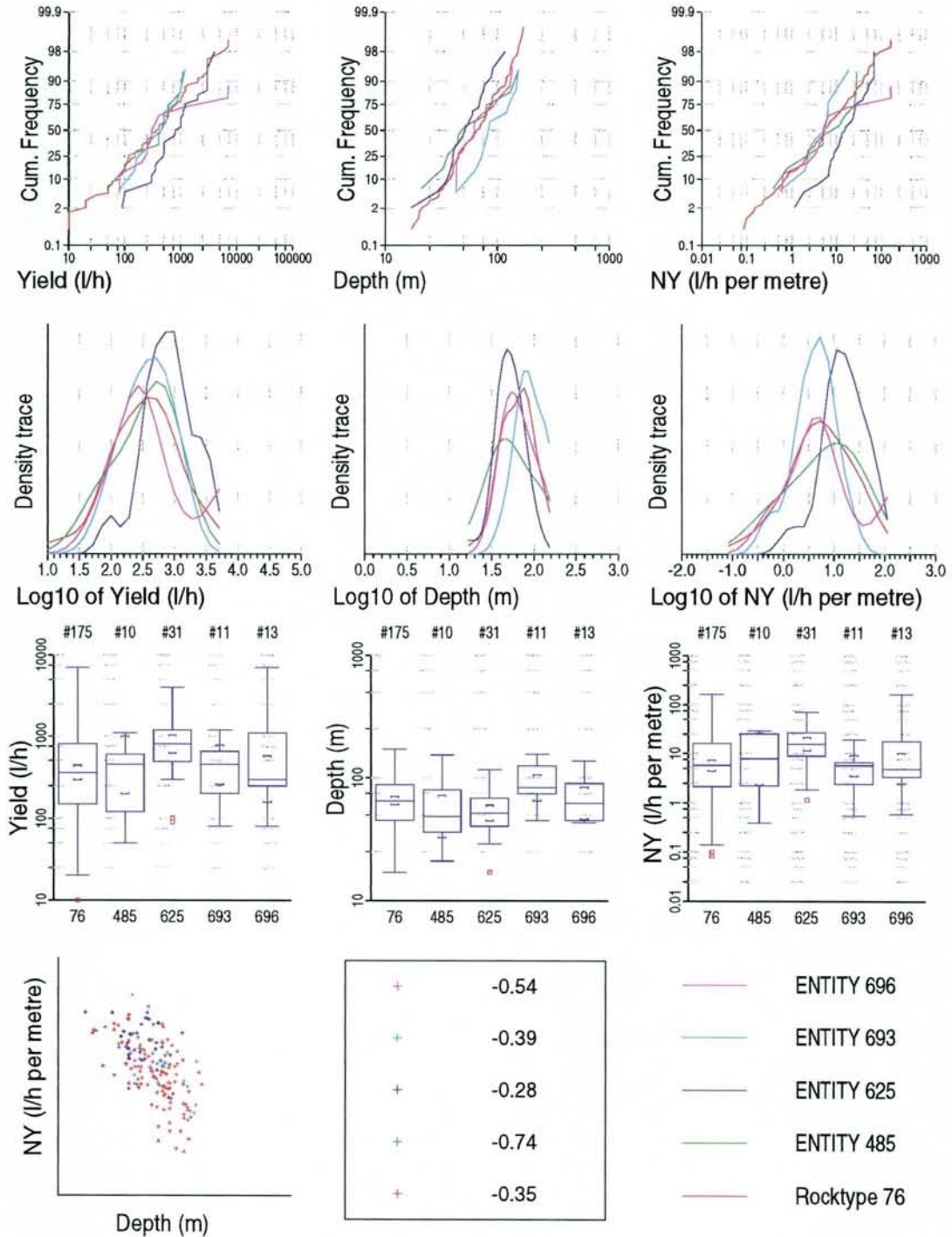
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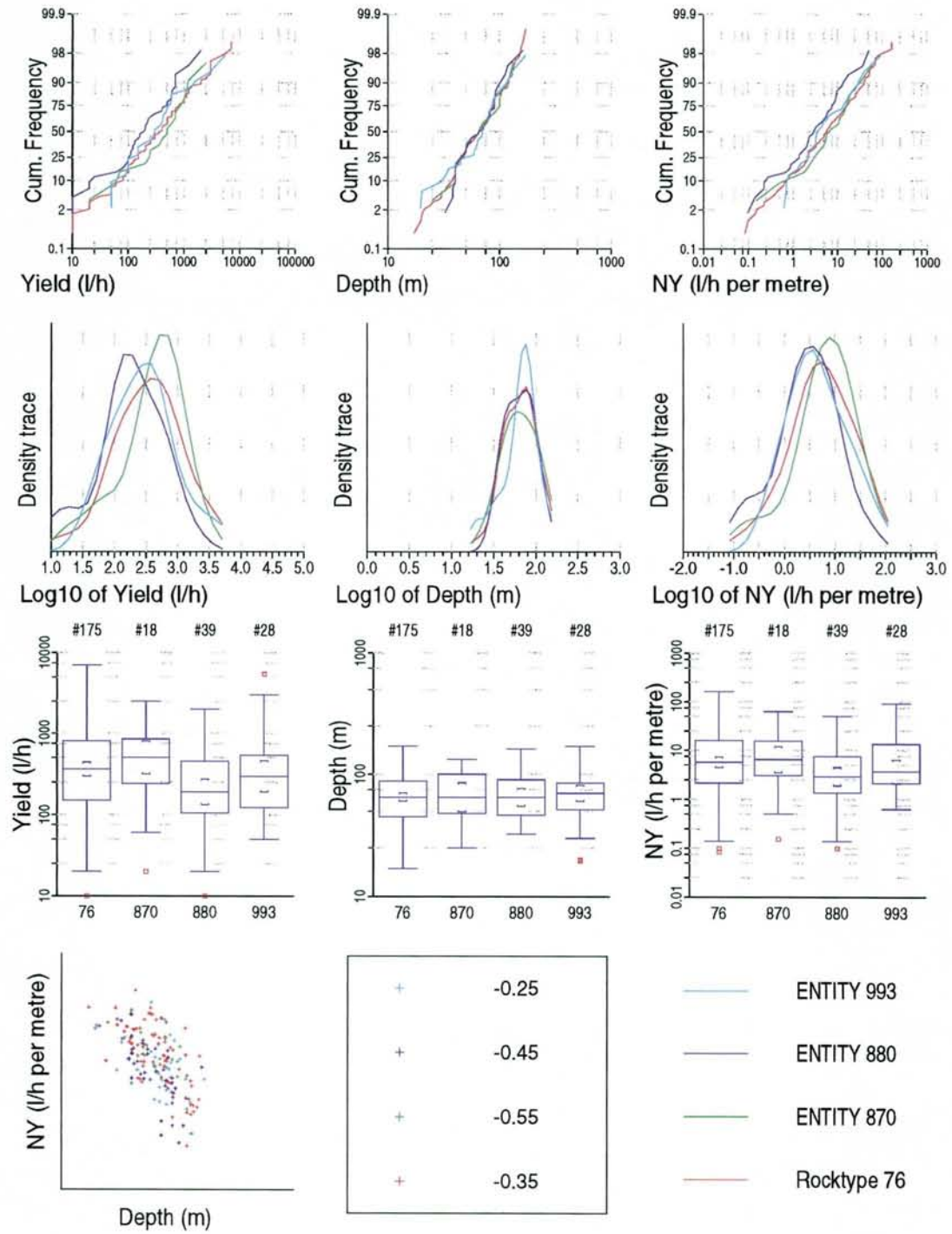
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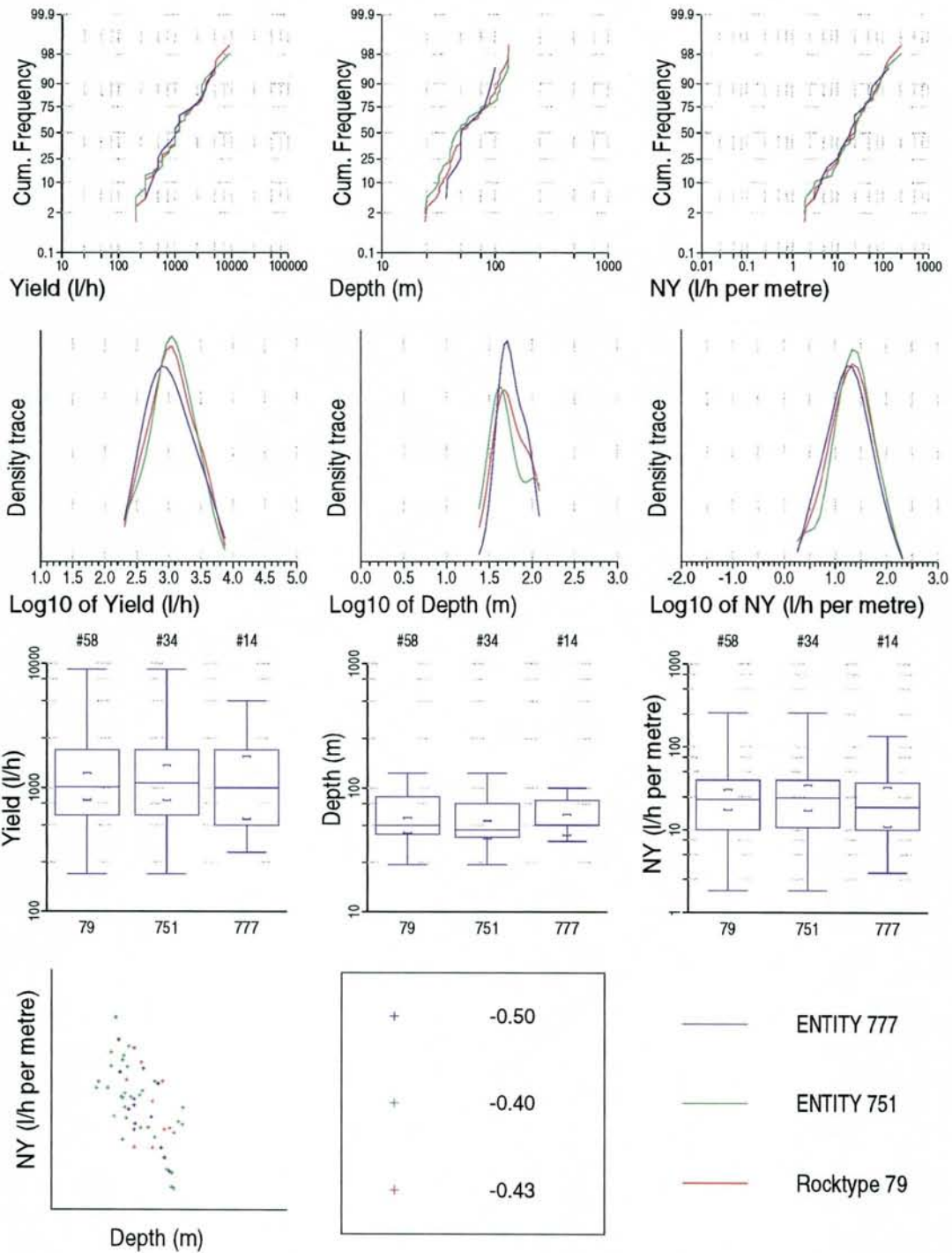
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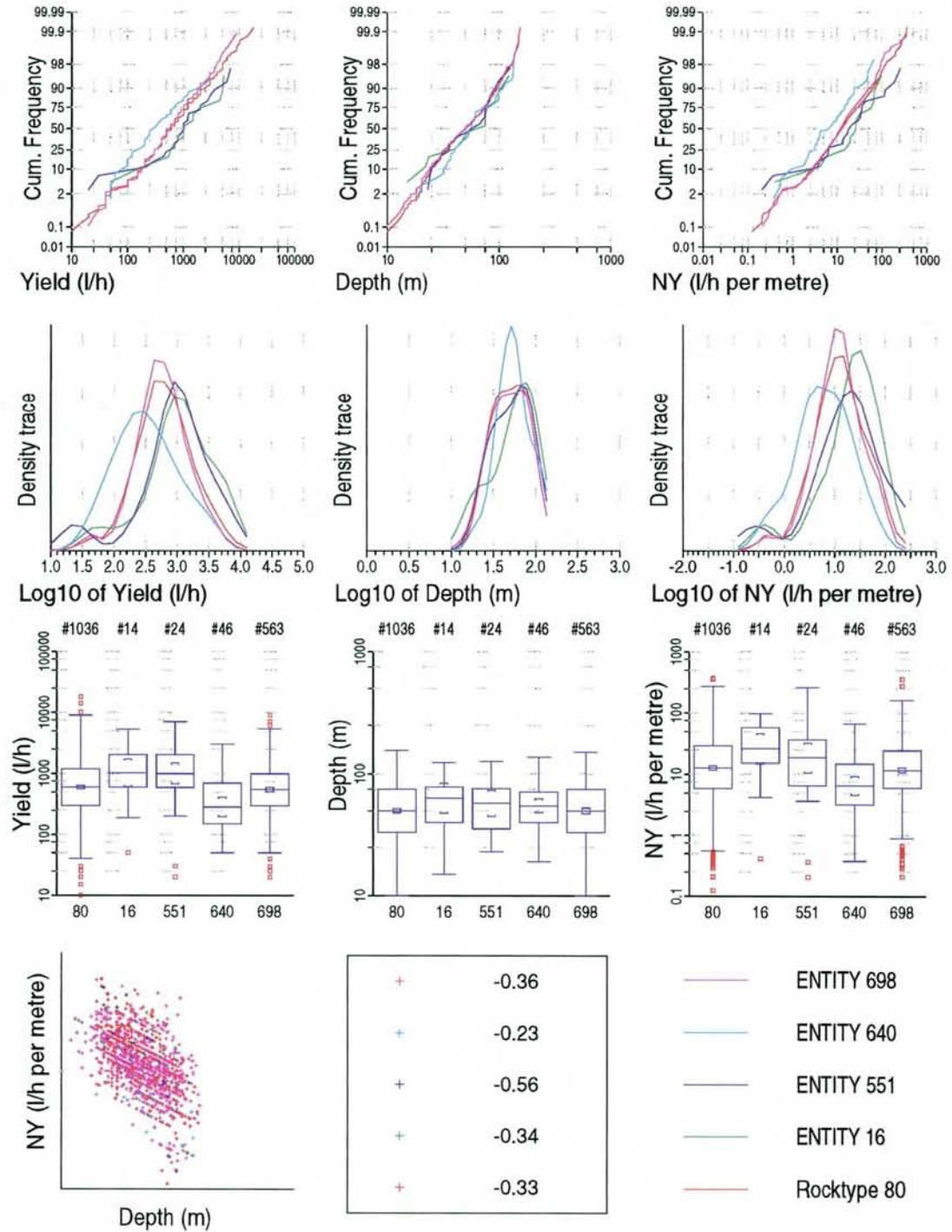
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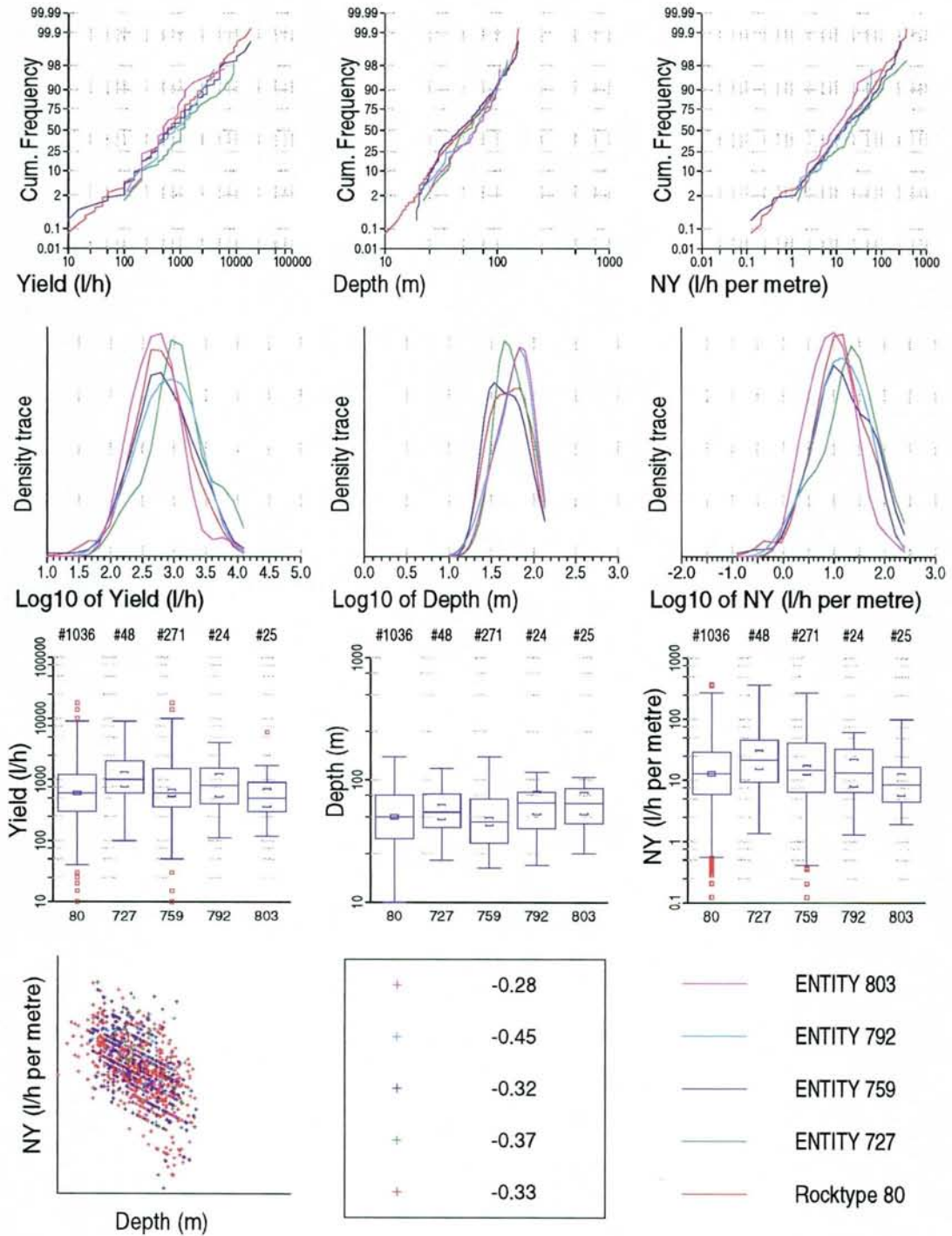
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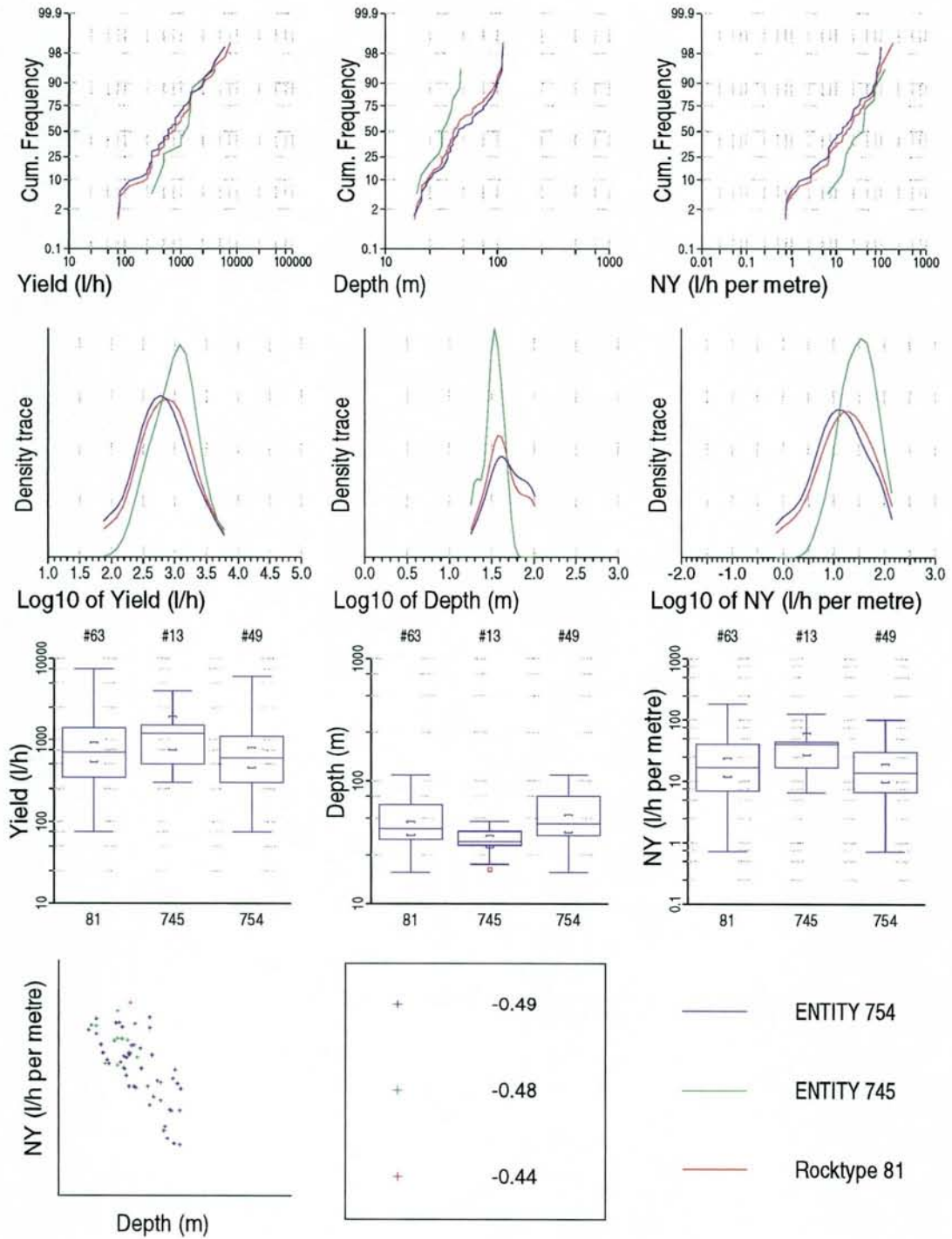
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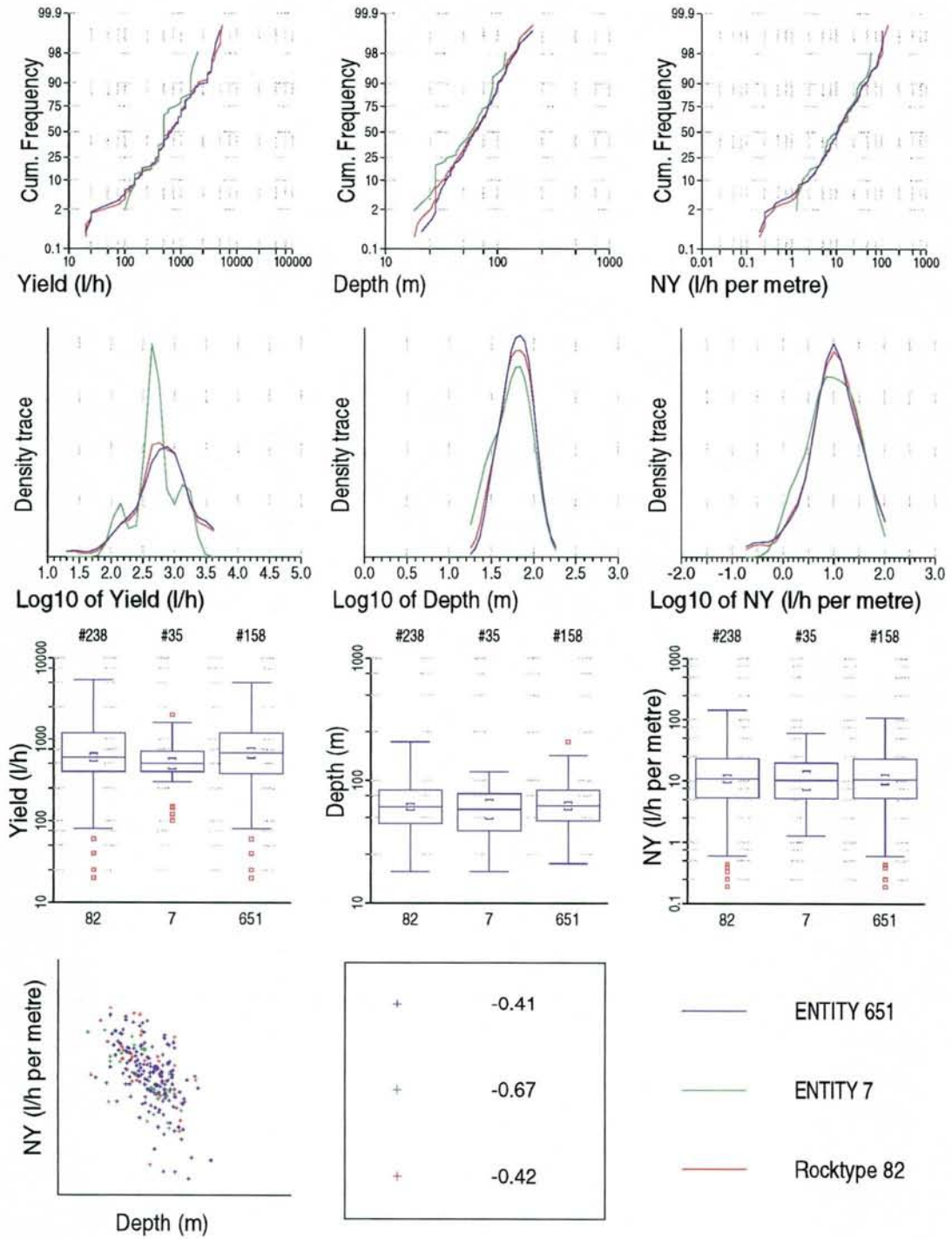
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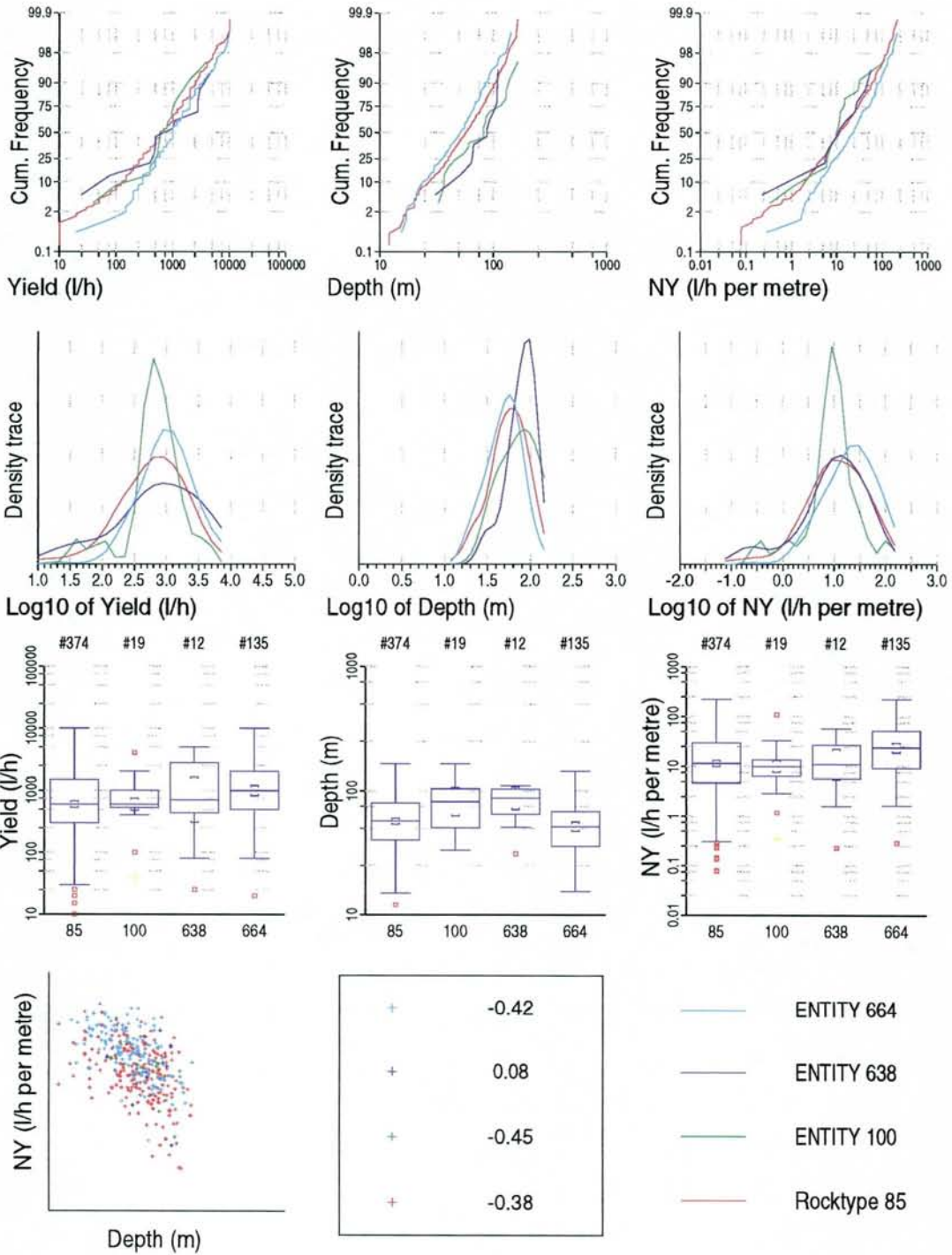
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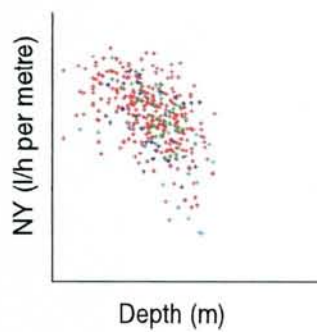
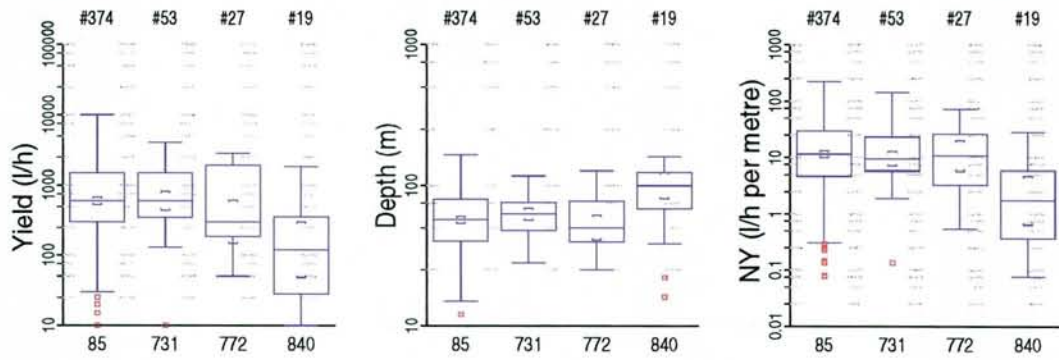
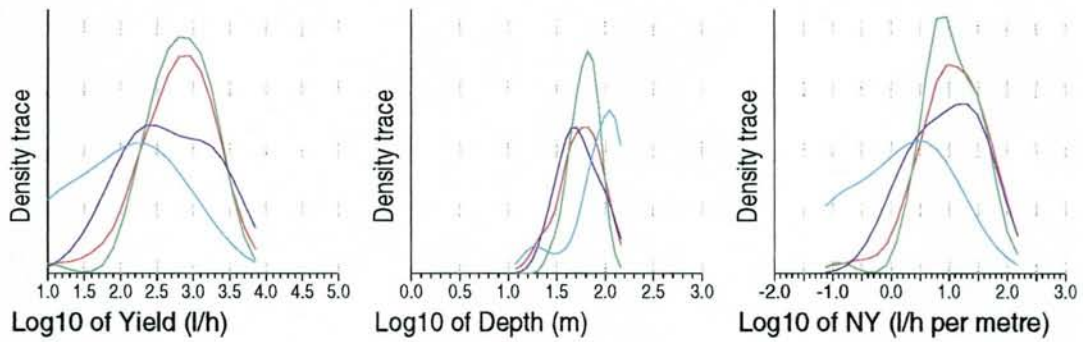
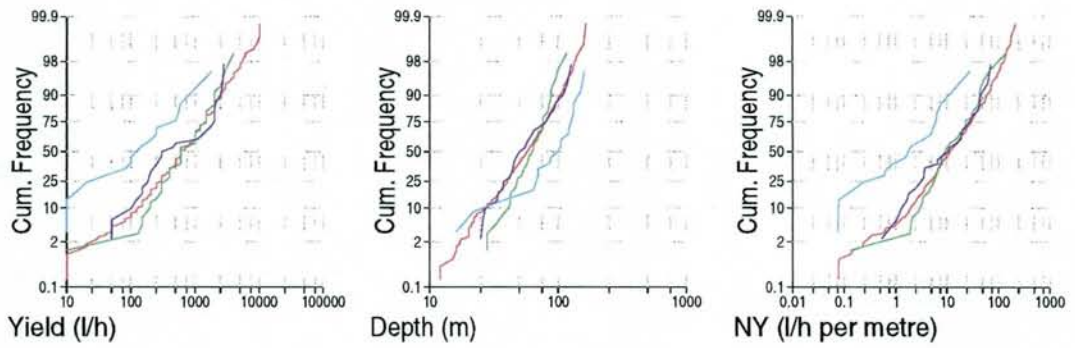
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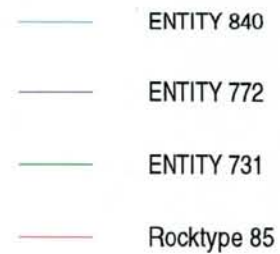
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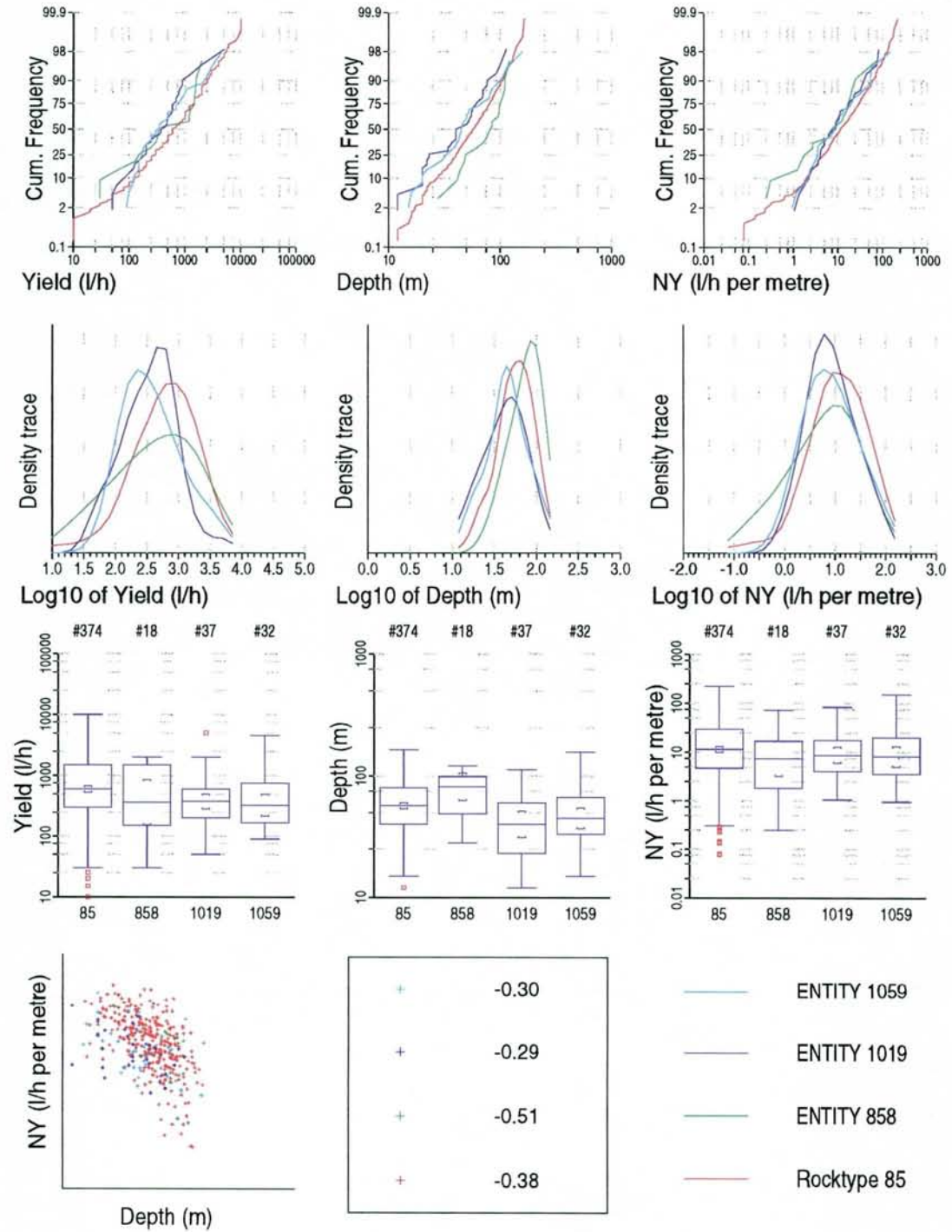
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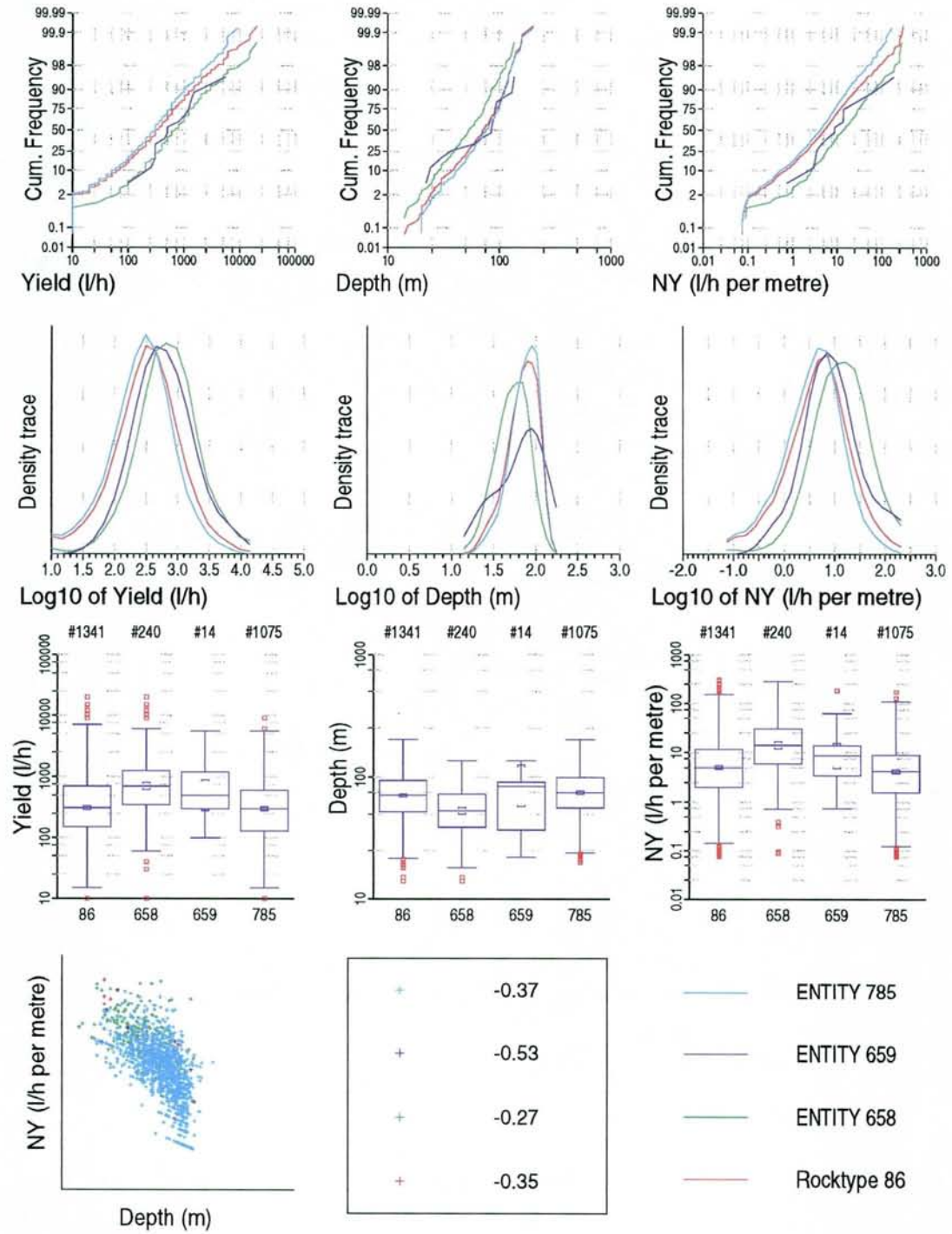
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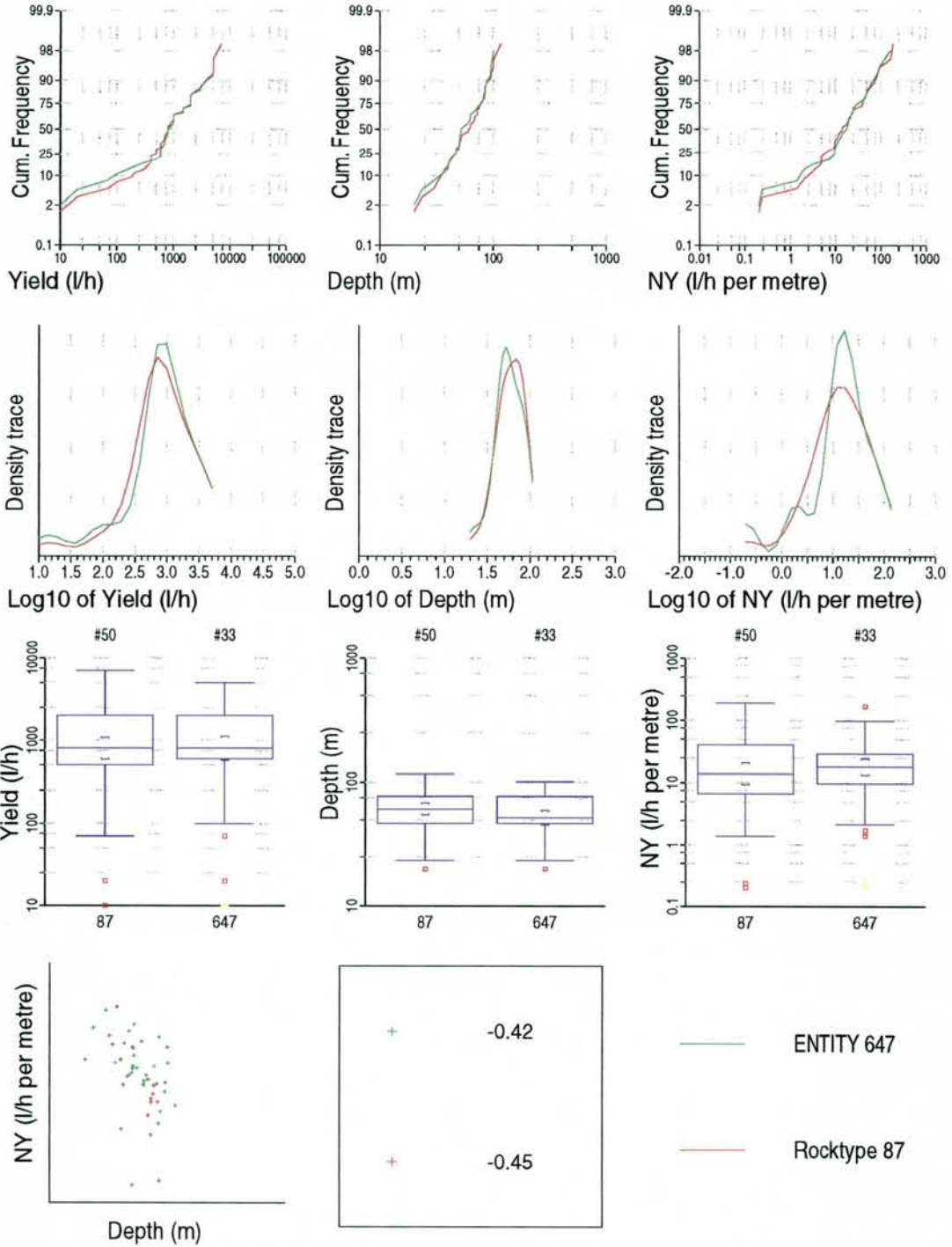
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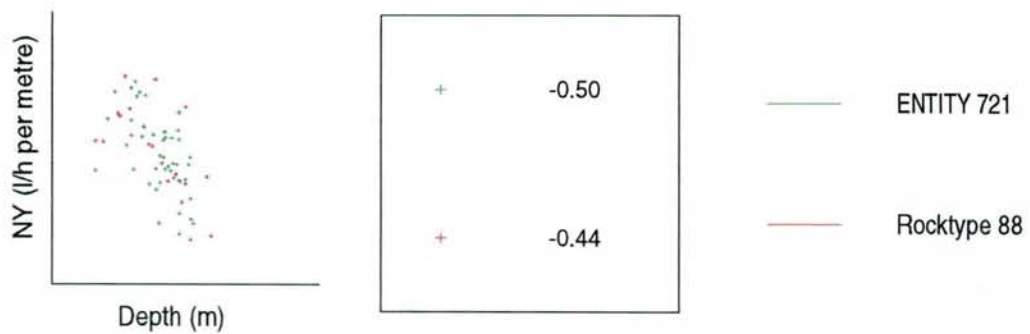
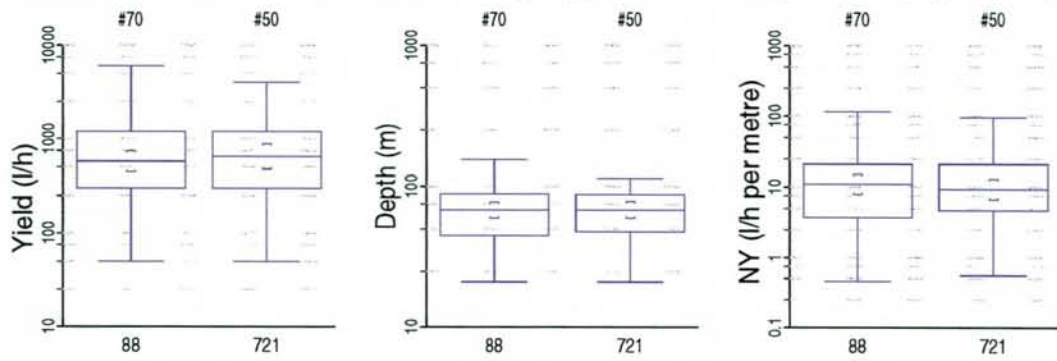
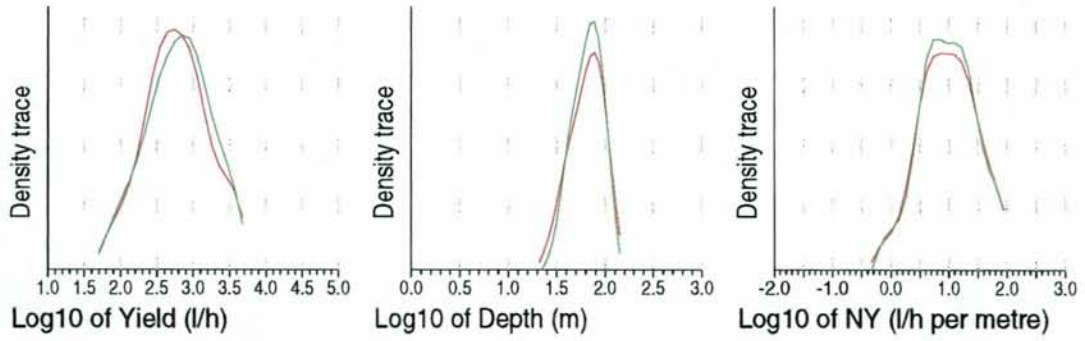
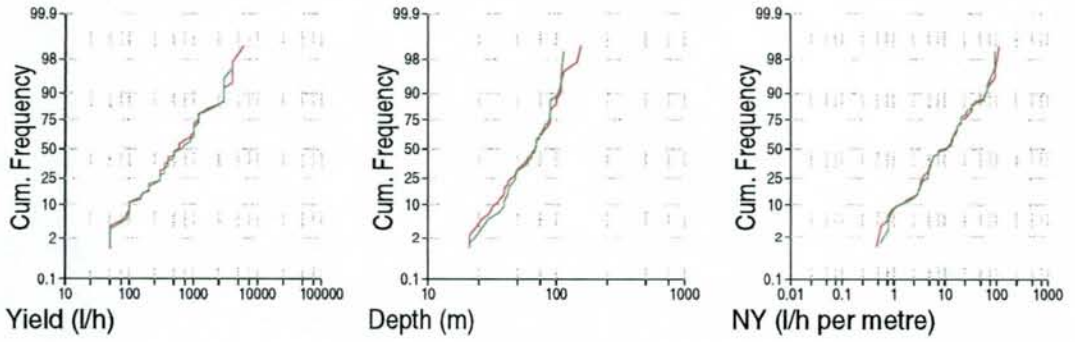
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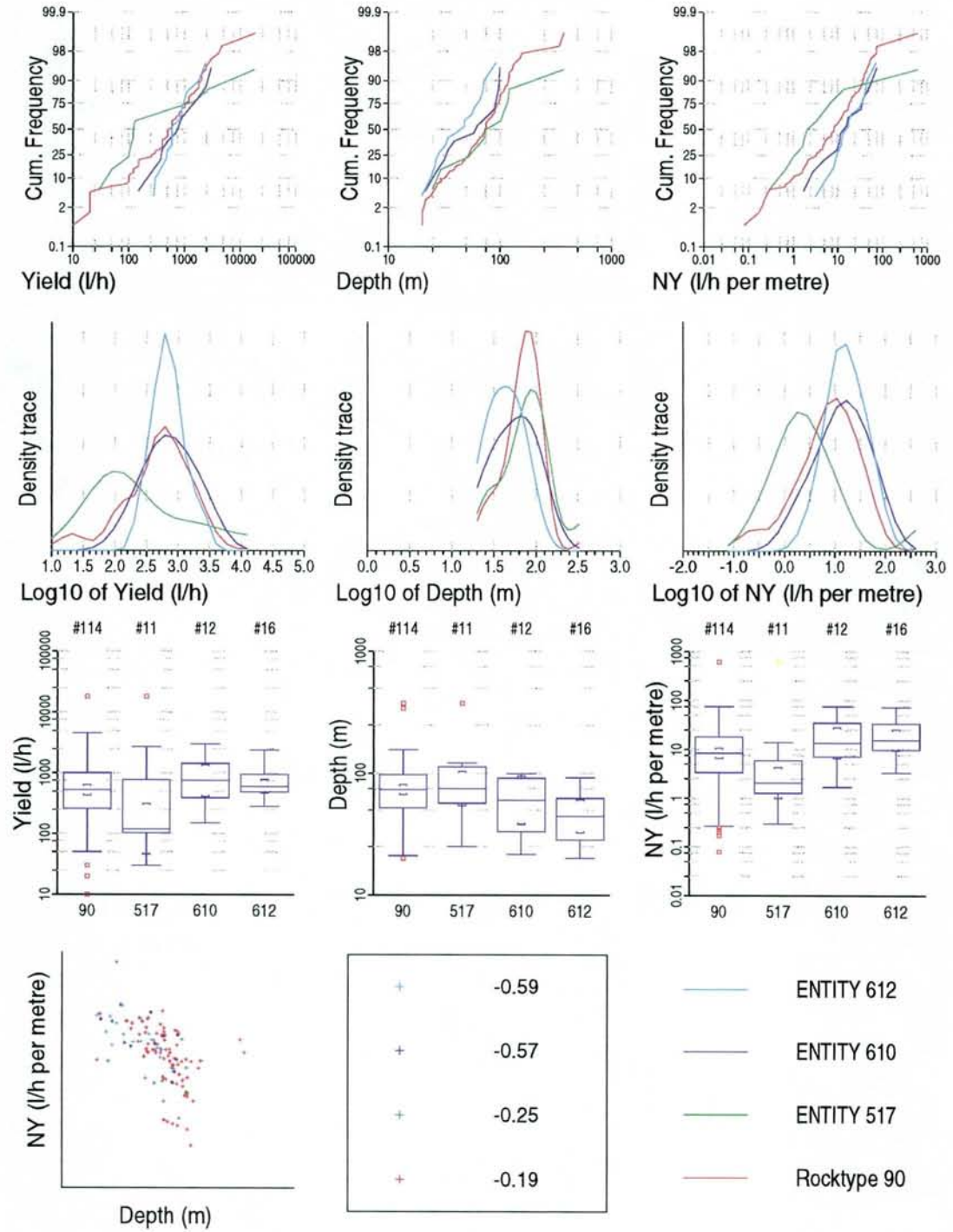
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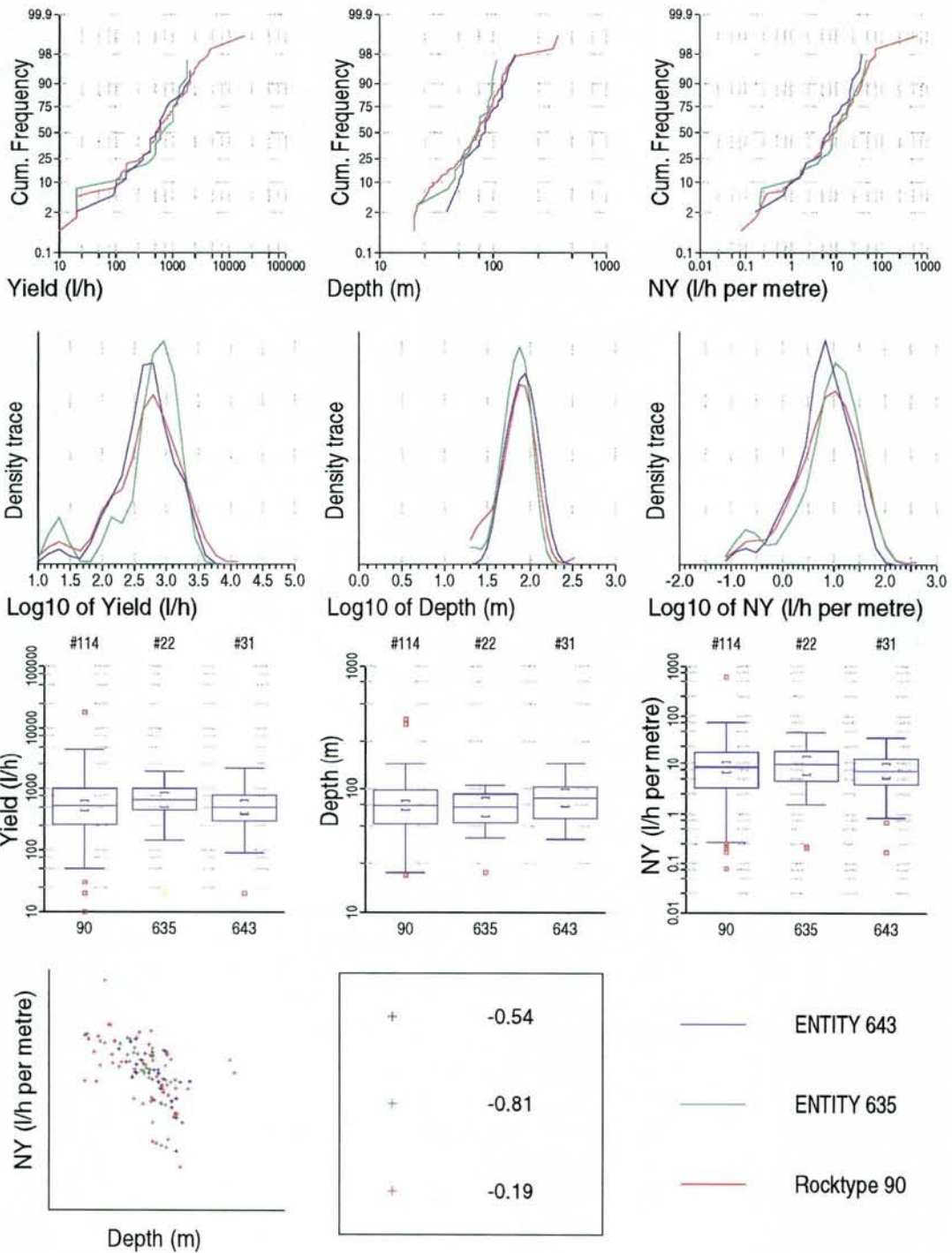
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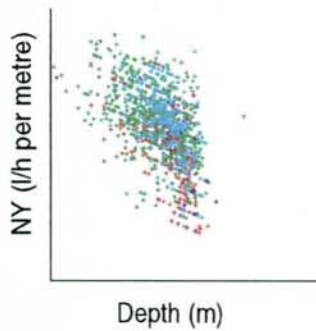
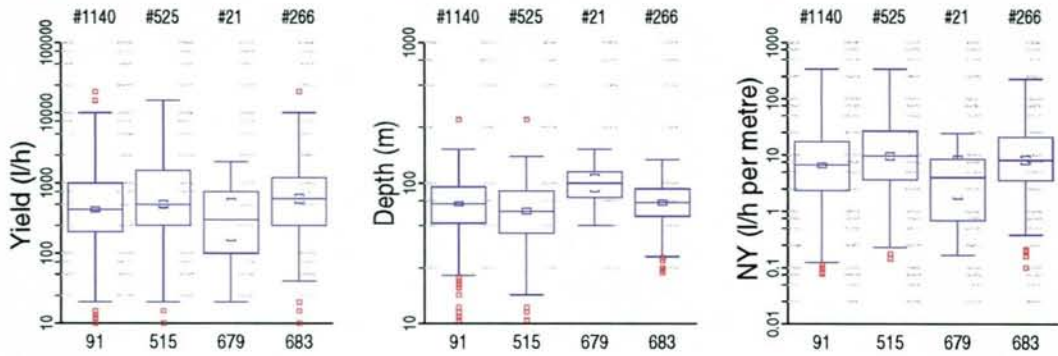
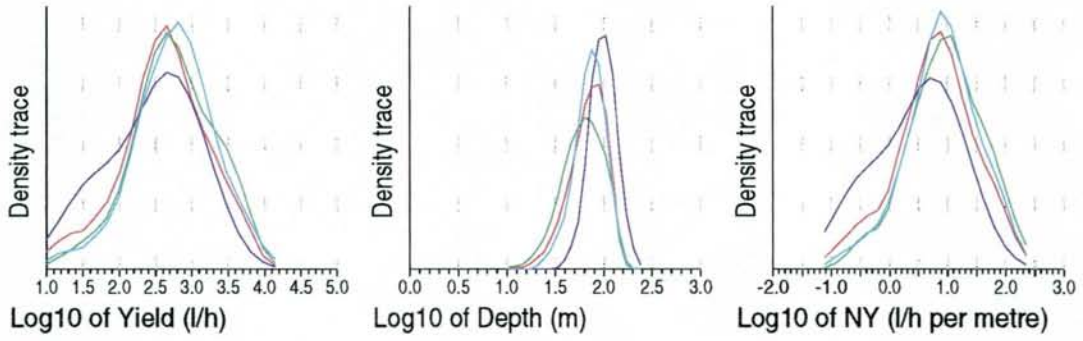
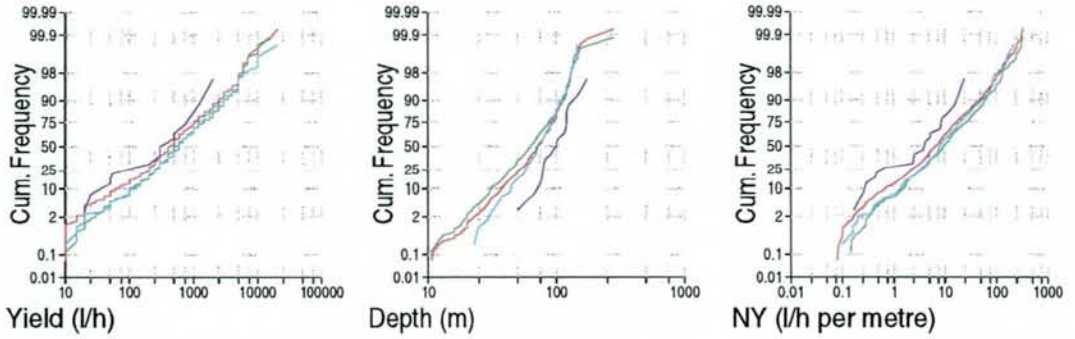
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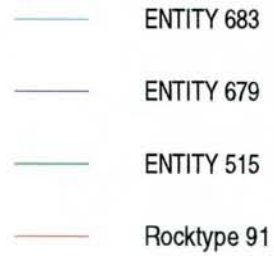
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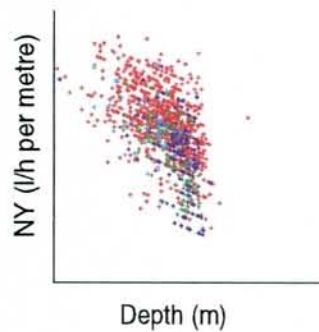
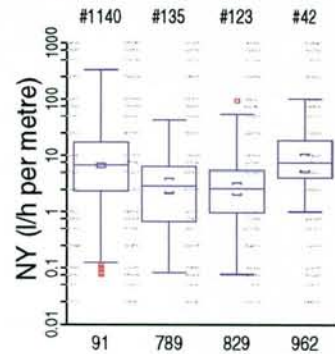
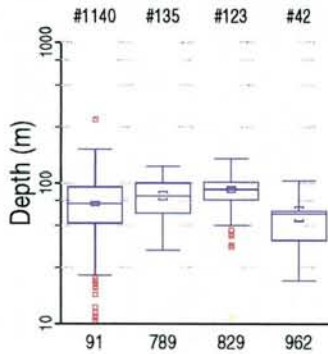
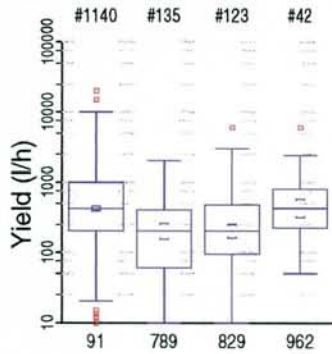
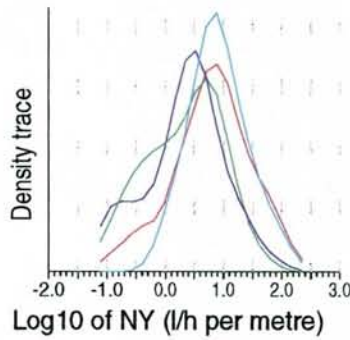
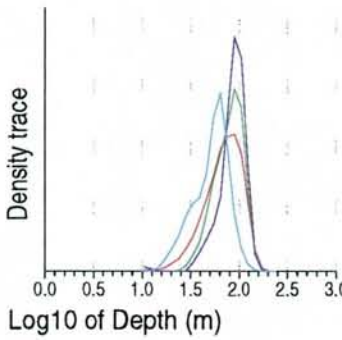
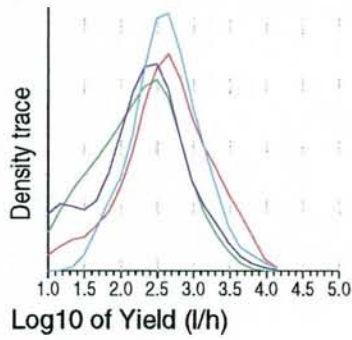
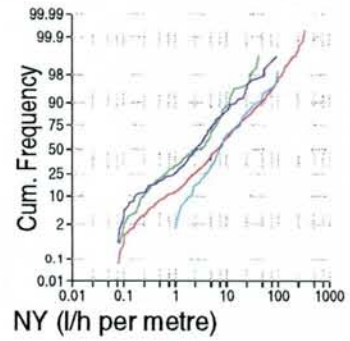
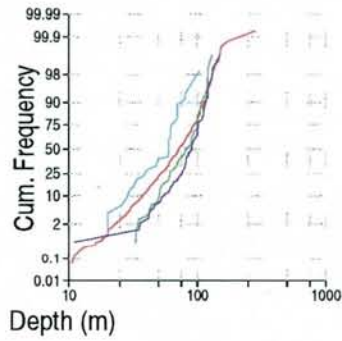
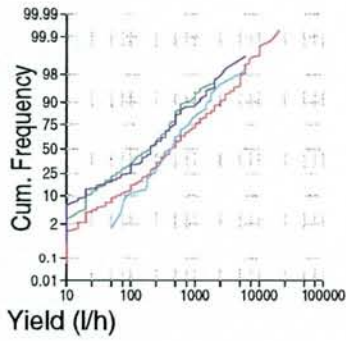
All boreholes within each entity



+	-0.33
+	-0.54
+	-0.36
+	-0.37



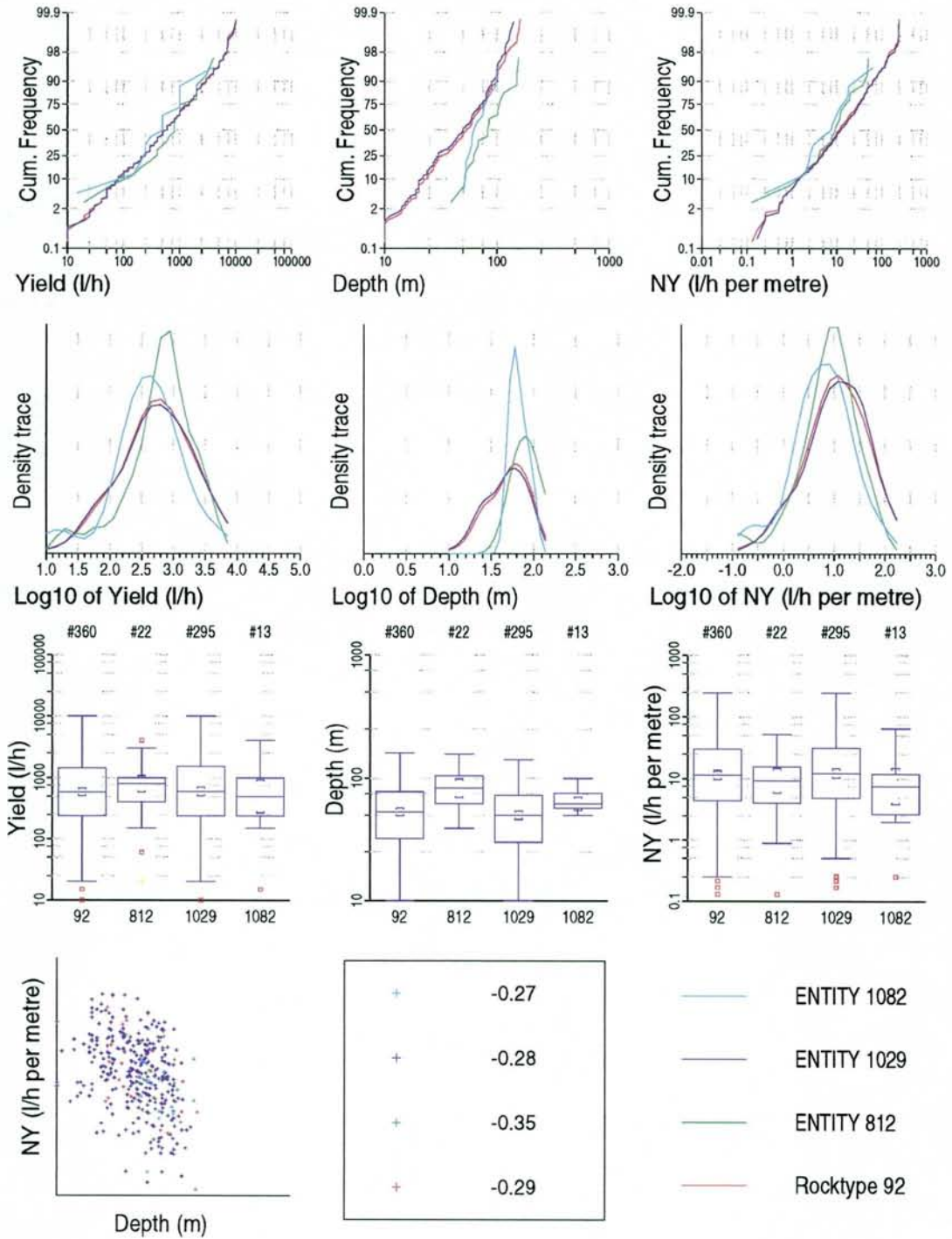
All boreholes within each entity



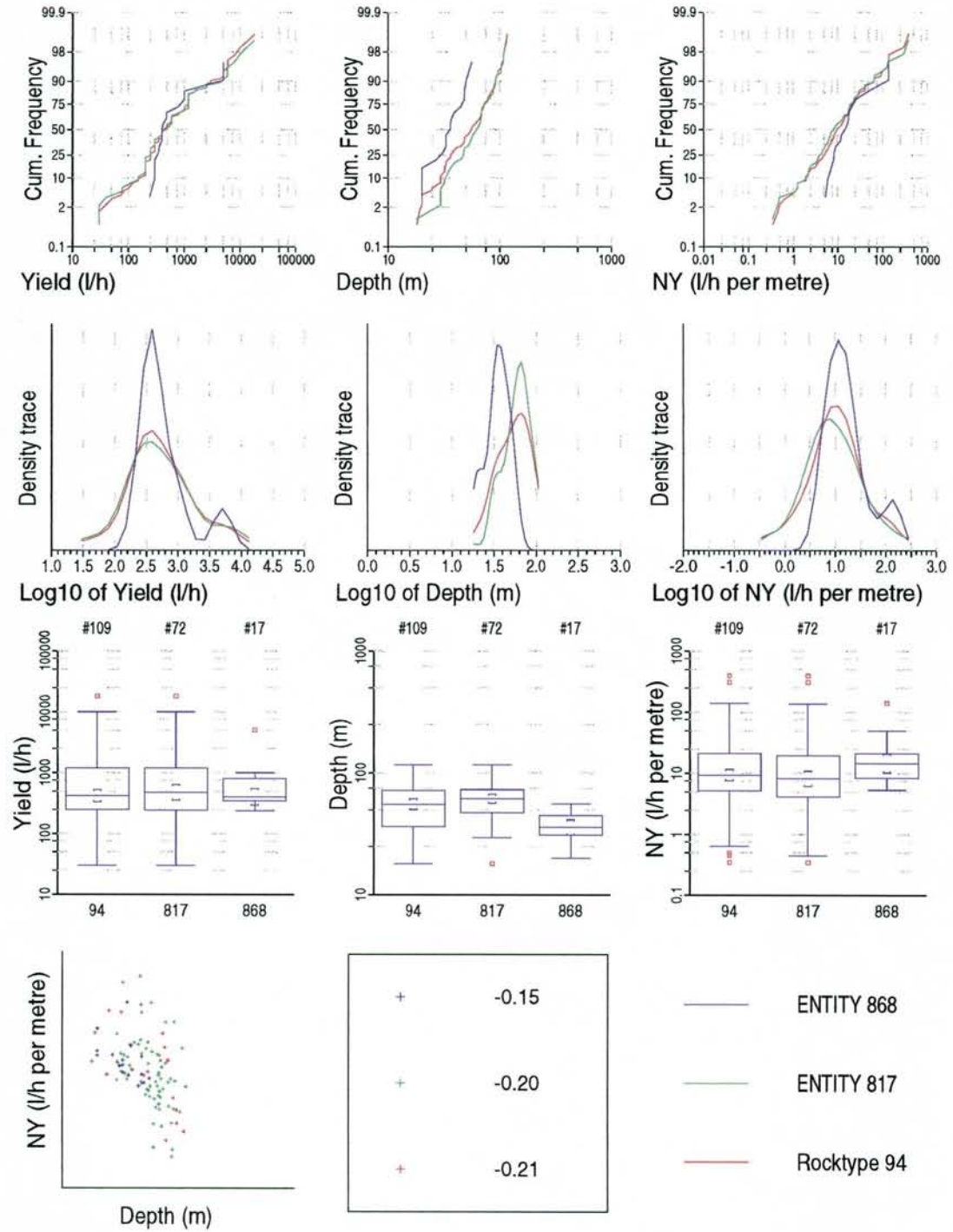
+	-0.34
+	-0.38
+	-0.42
+	-0.37

- ENTITY 962
- ENTITY 829
- ENTITY 789
- Rocktype 91

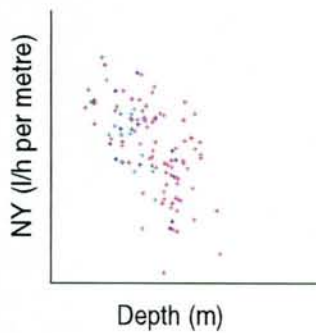
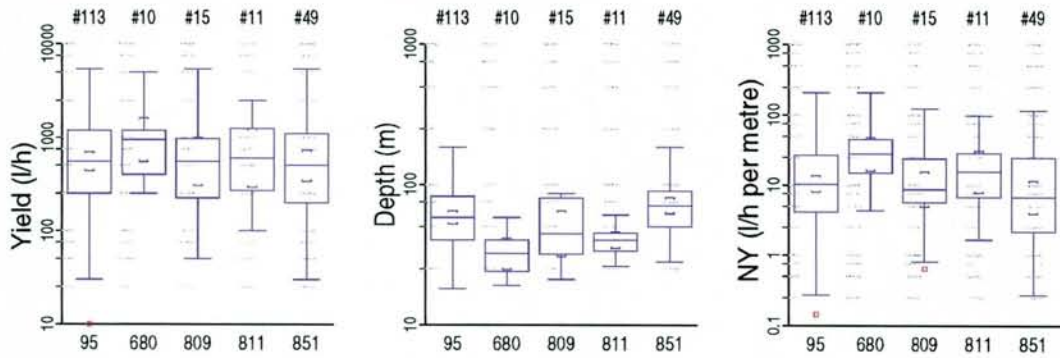
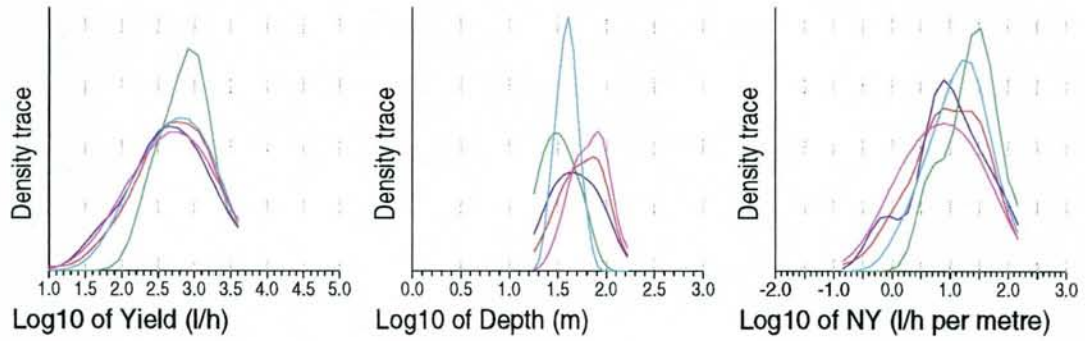
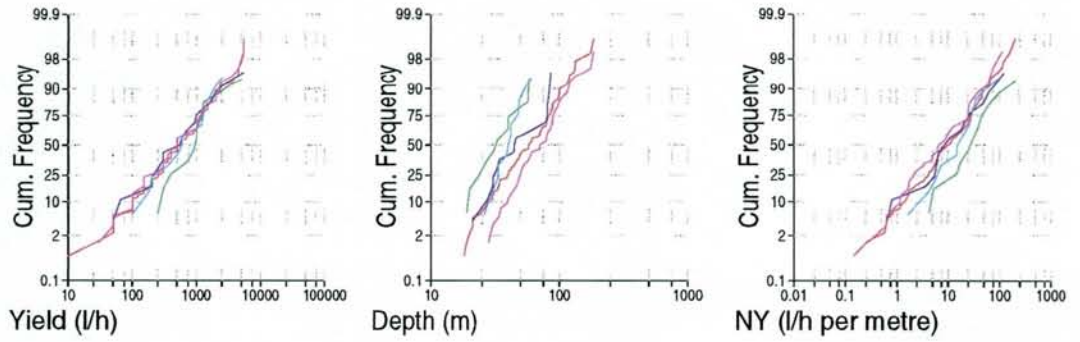
All boreholes within each entity



All boreholes within each entity



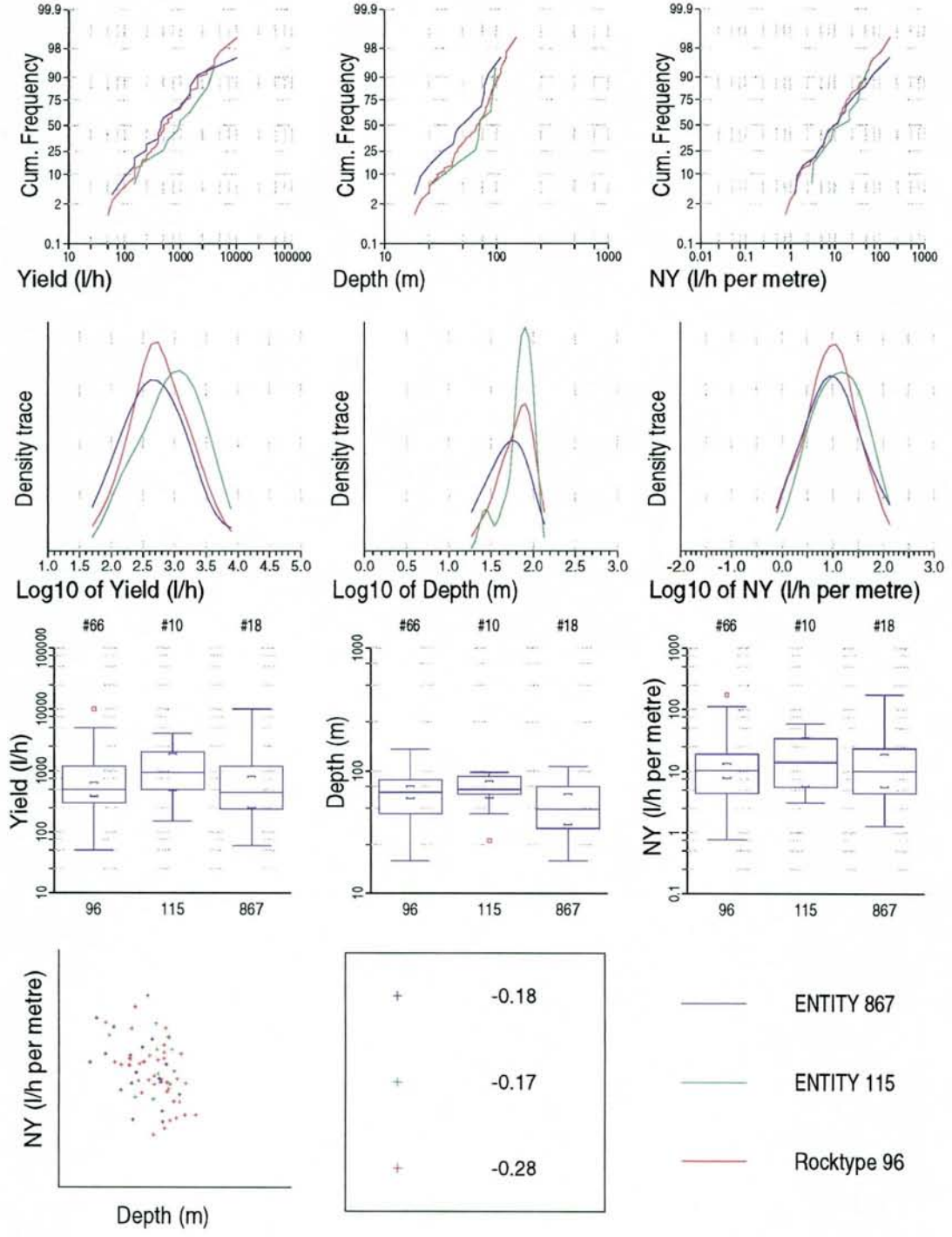
All boreholes within each entity



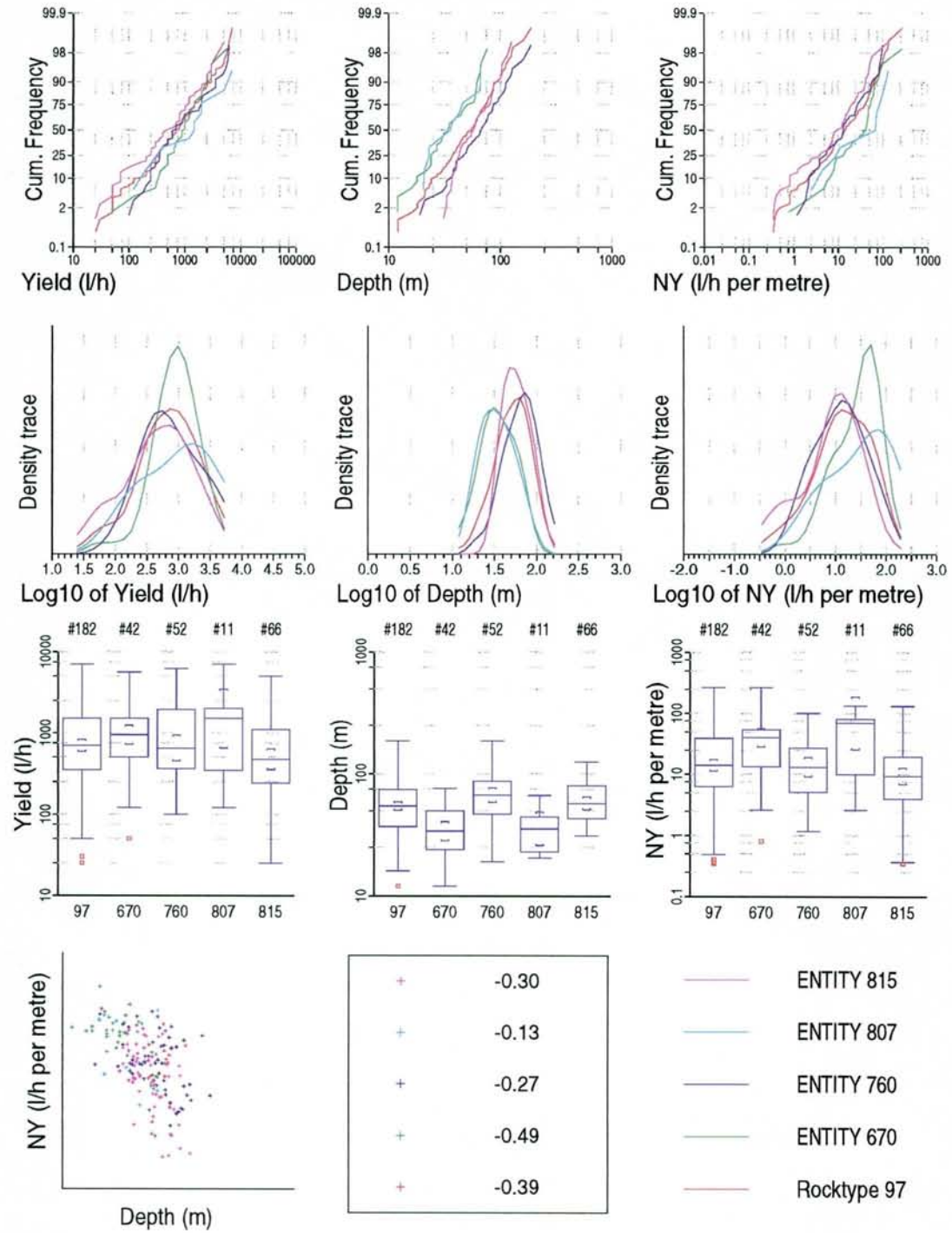
+	-0.43
+	-0.53
+	-0.37
+	-0.52
+	-0.39

- ENTITY 851
- ENTITY 811
- ENTITY 809
- ENTITY 680
- Rocktype 95

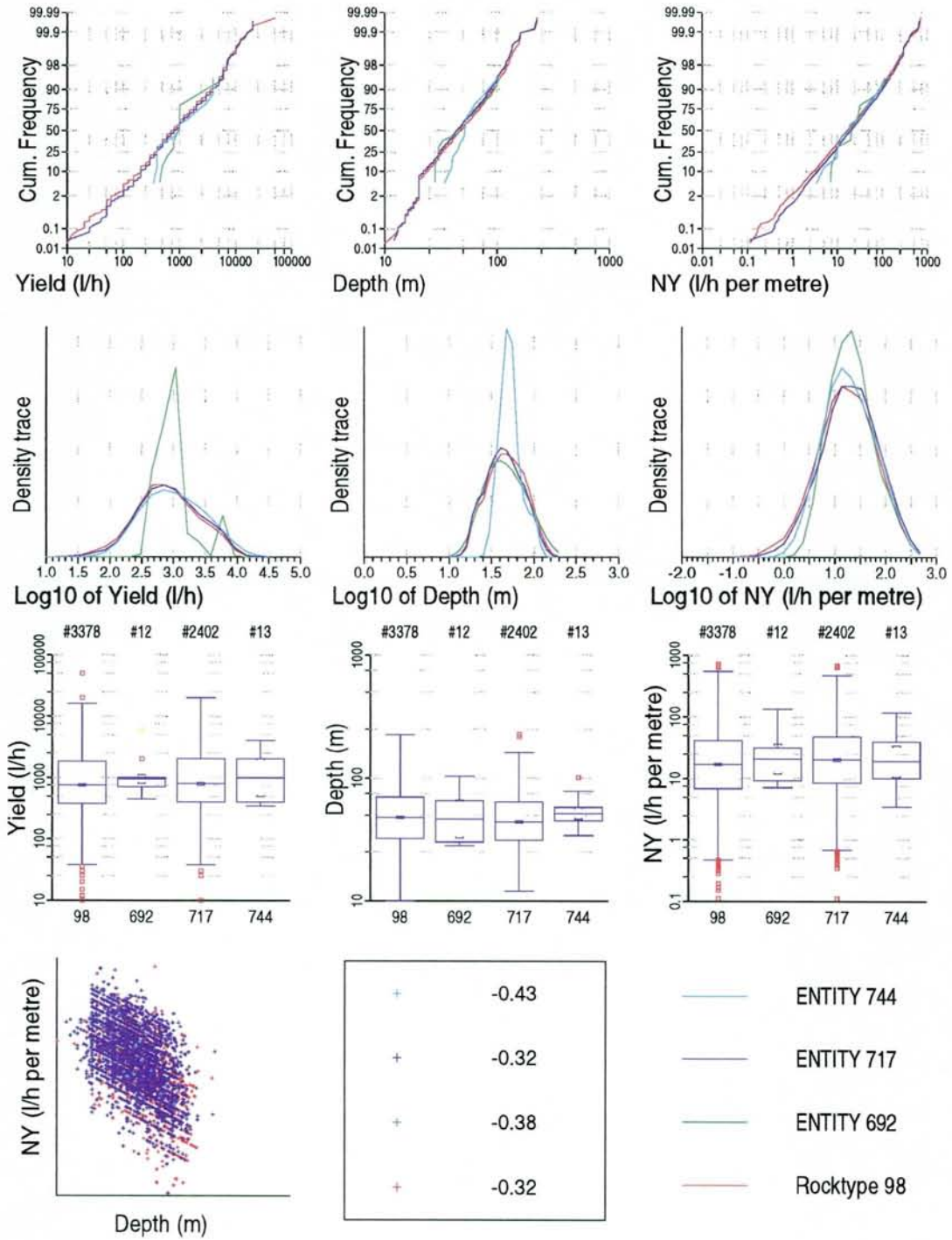
All boreholes within each entity



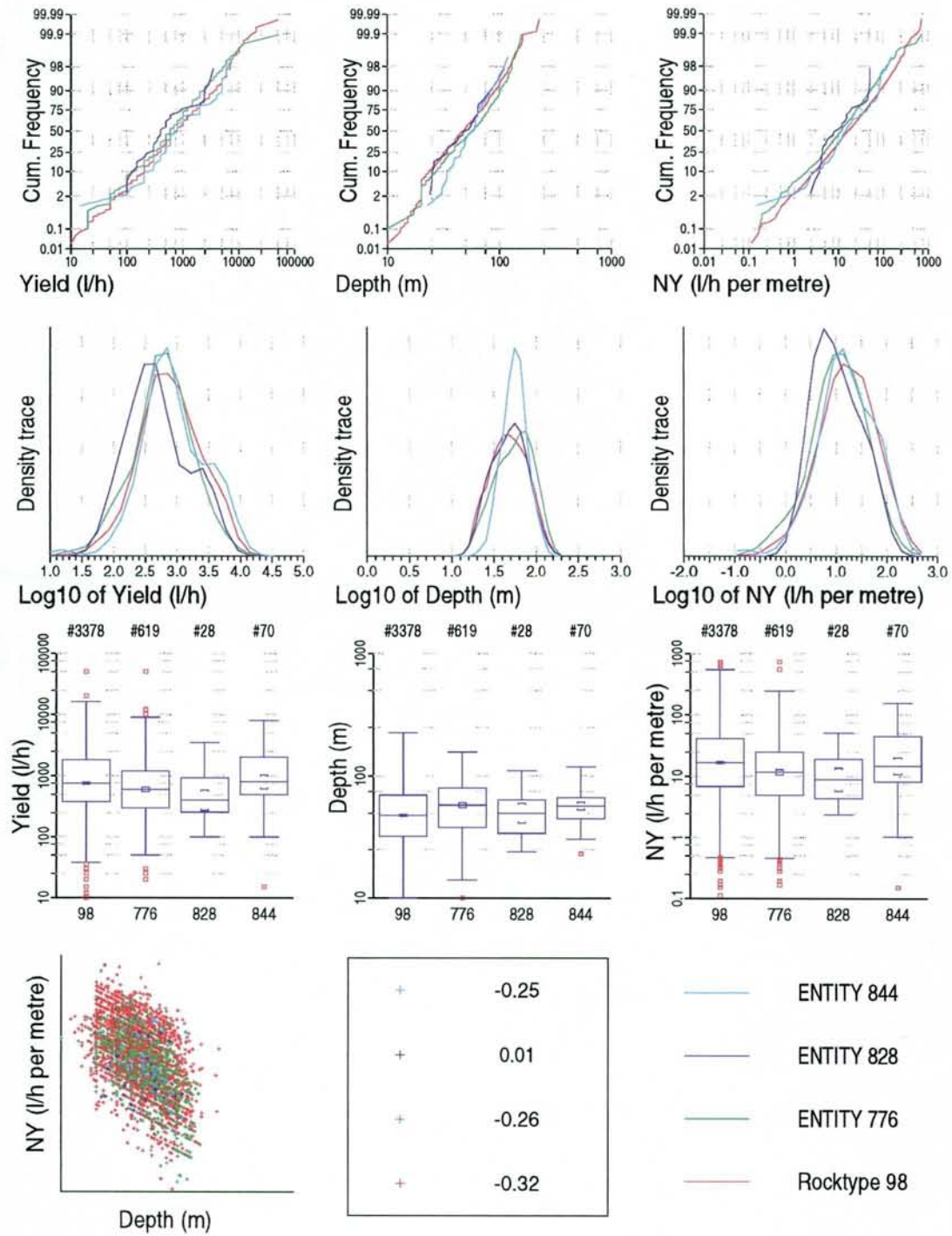
All boreholes within each entity



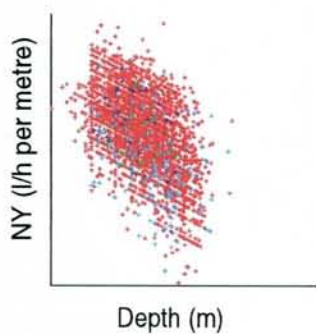
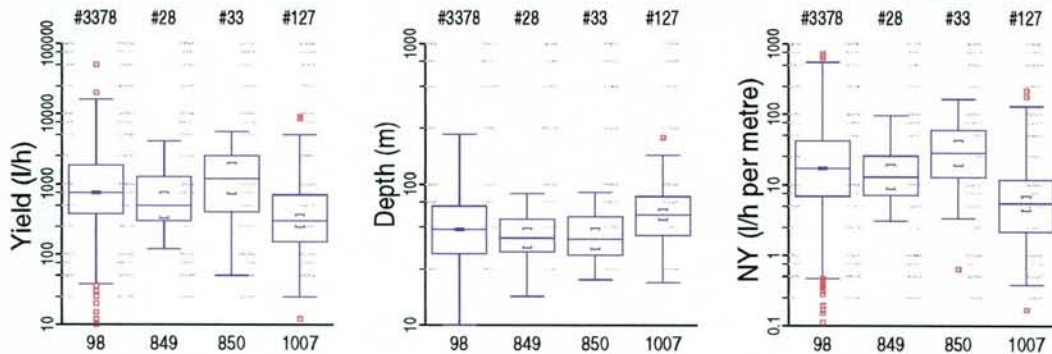
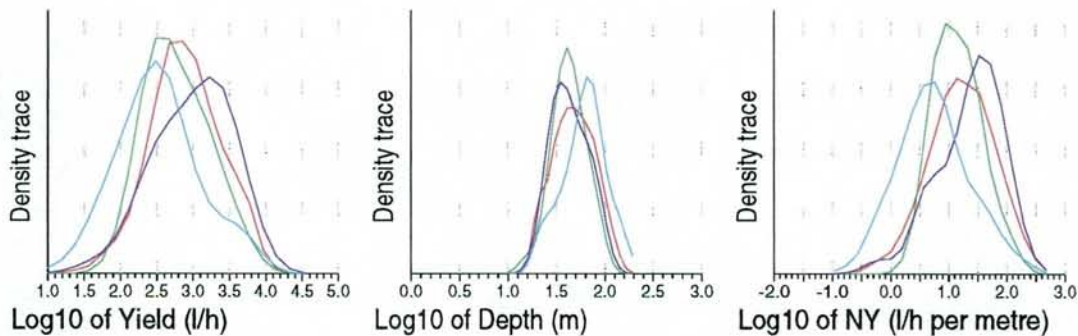
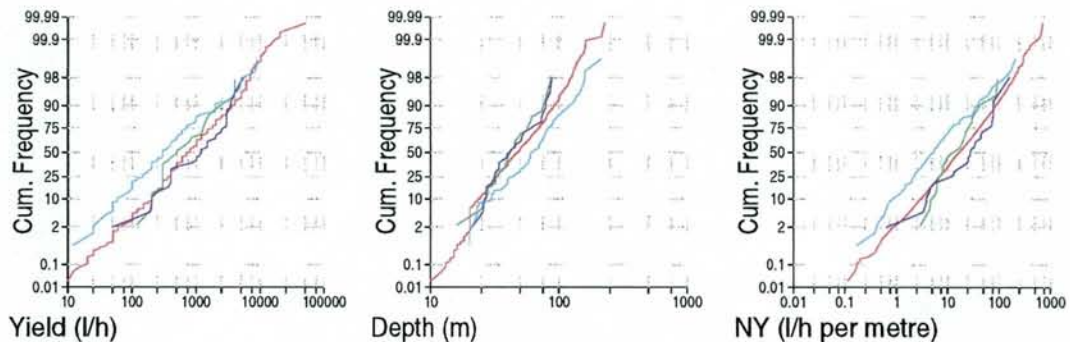
All boreholes within each entity



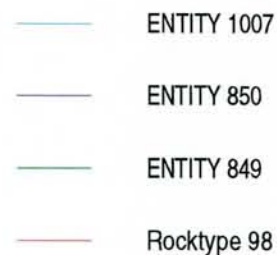
All boreholes within each entity



All boreholes within each entity

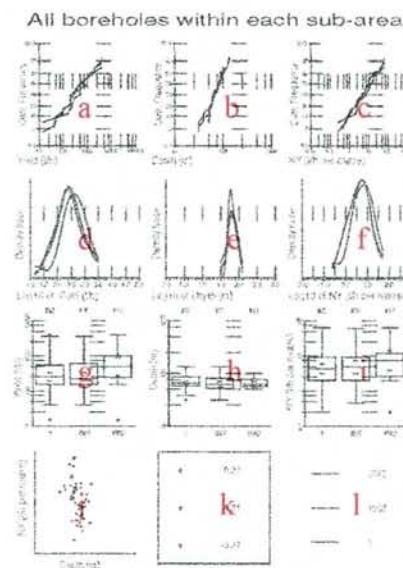


+	-0.21
+	-0.35
+	-0.05
+	-0.32



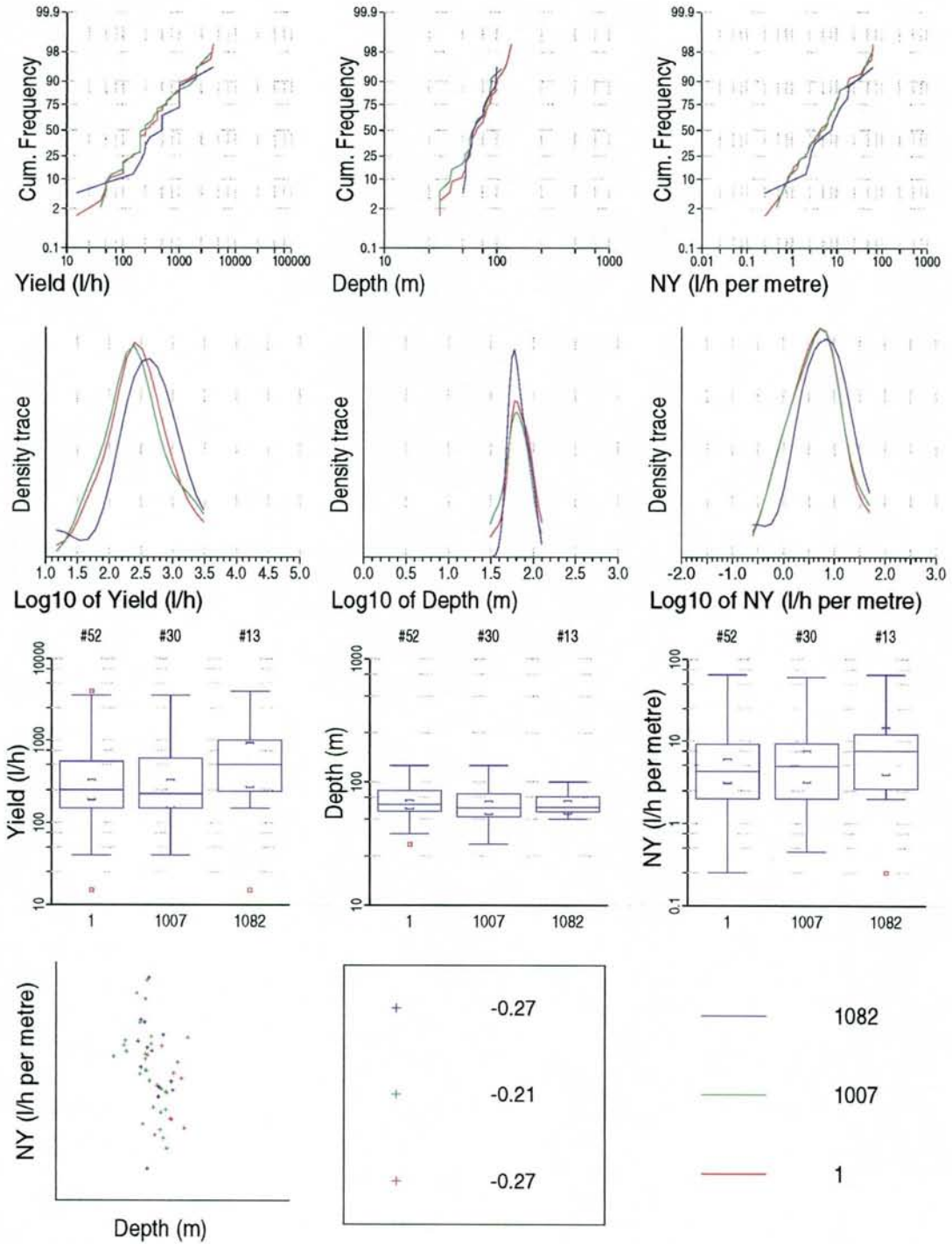
Appendix C

Graphical presentation of all boreholes within each sub-area

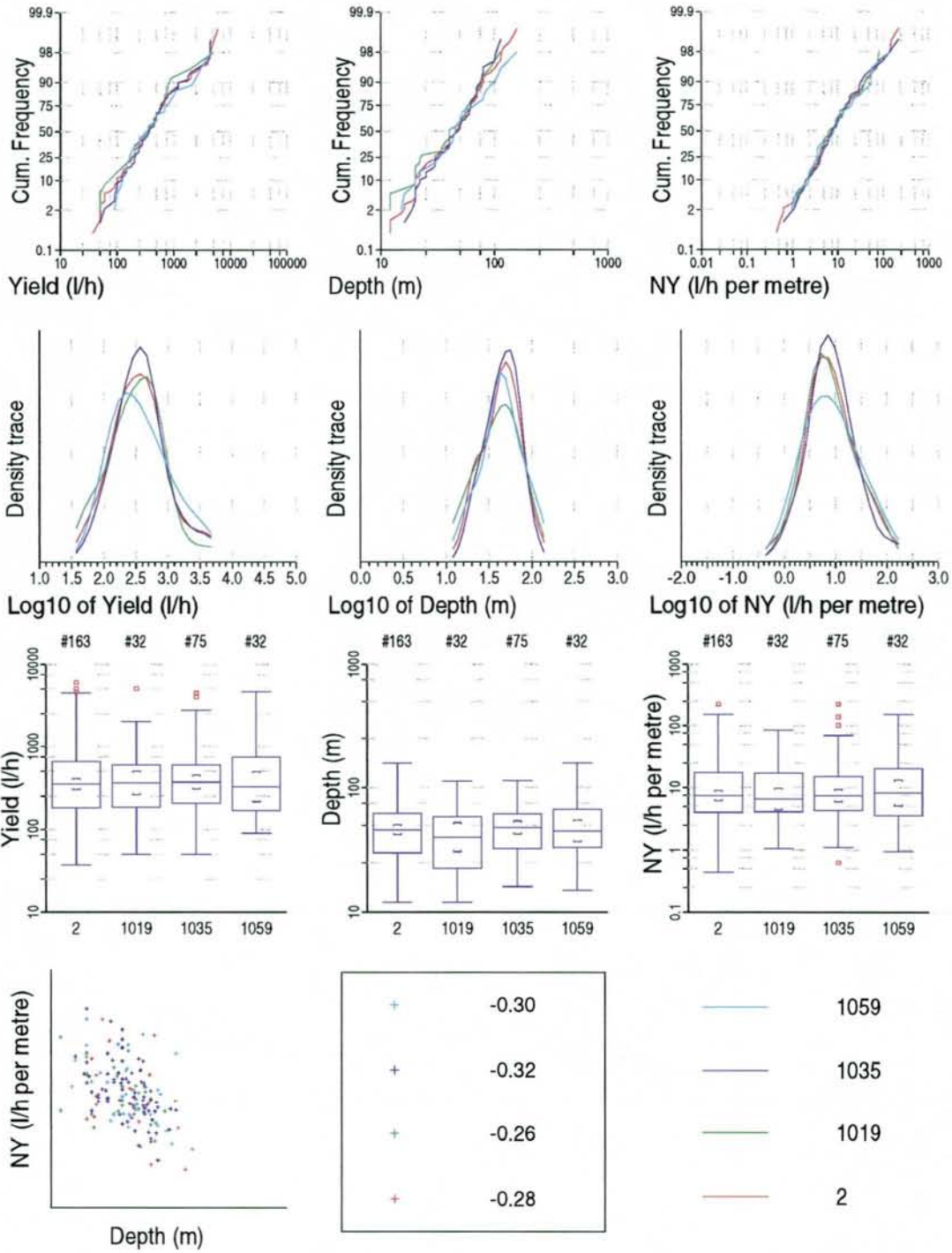


- a: CDF diagram; yield (L/h)
- b: CDF diagram; depth (m)
- c: CDF diagram; normalised yield (L/h per metre)
- d: Density trace diagram; yield (L/h)
- e: Density trace diagram; depth (m)
- f: Density trace diagram; normalised yield (L/h per metre)
- g: Boxplot diagram; yield (L/h)
- h: Boxplot diagram; depth (m)
- i: Boxplot diagram; normalised yield (L/h per metre)
- j: XY-diagram; depth (m) and normalised yield (L/h per metre)
- k: Pearson's r; depth (m) and normalised yield (L/h per metre)
- l: Legend

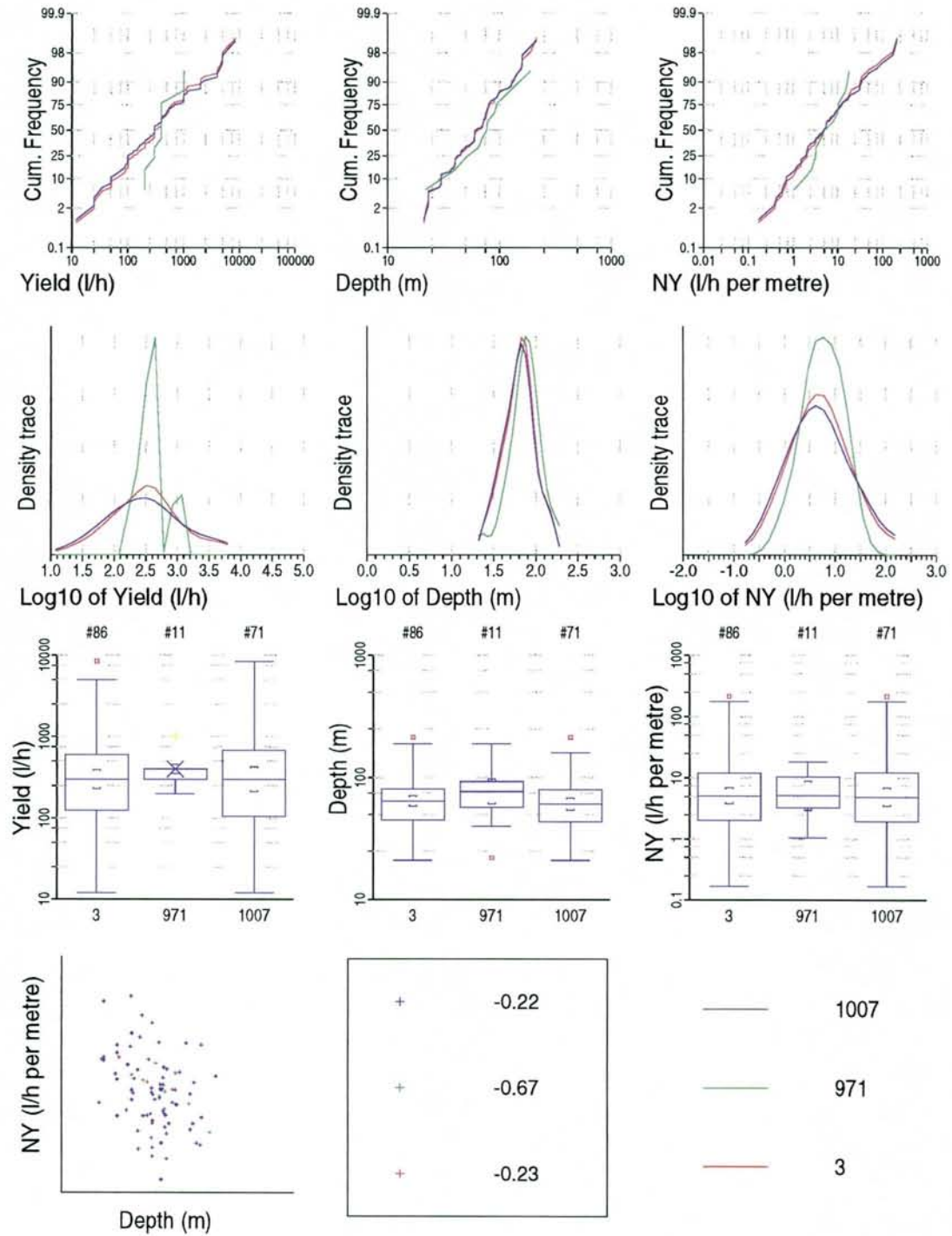
All boreholes within each sub-area



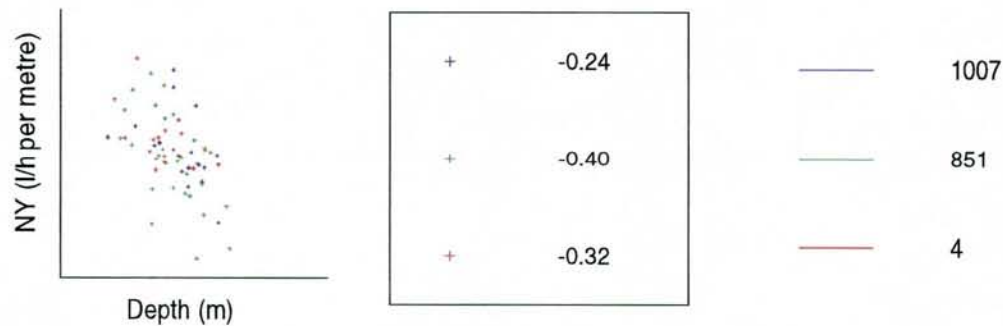
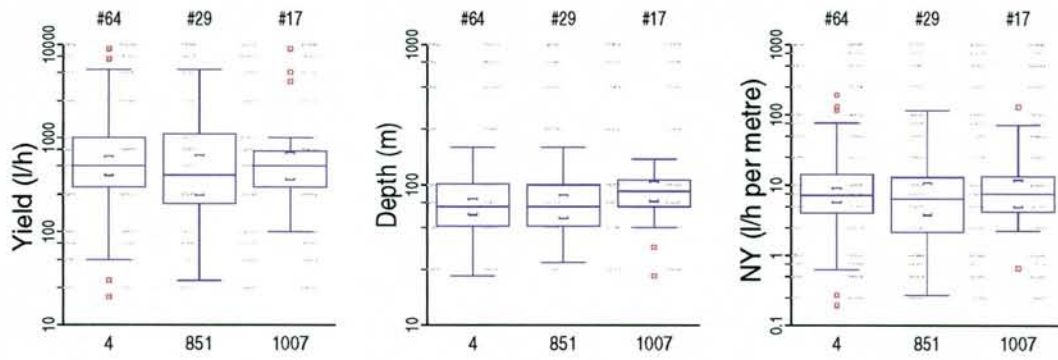
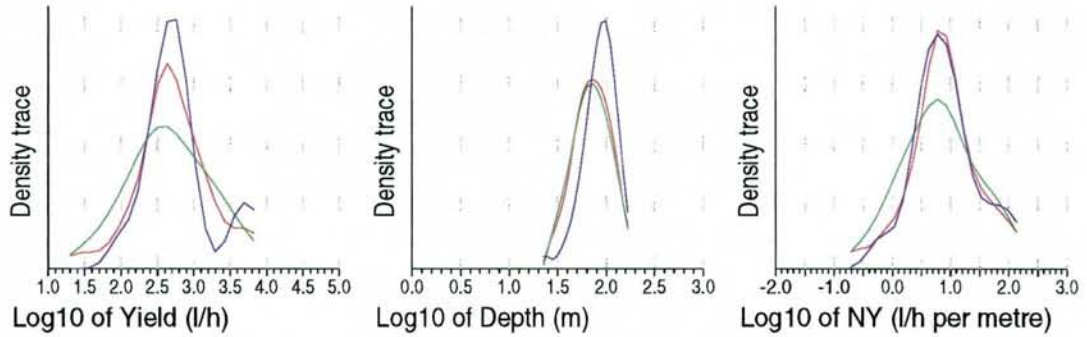
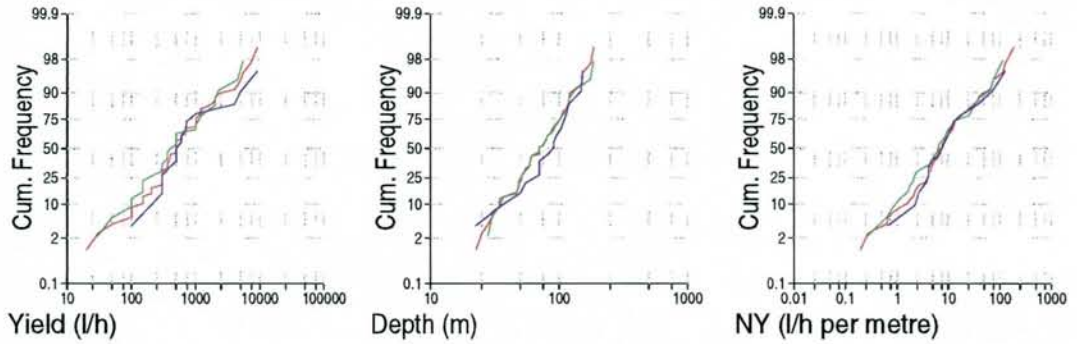
All boreholes within each sub-area



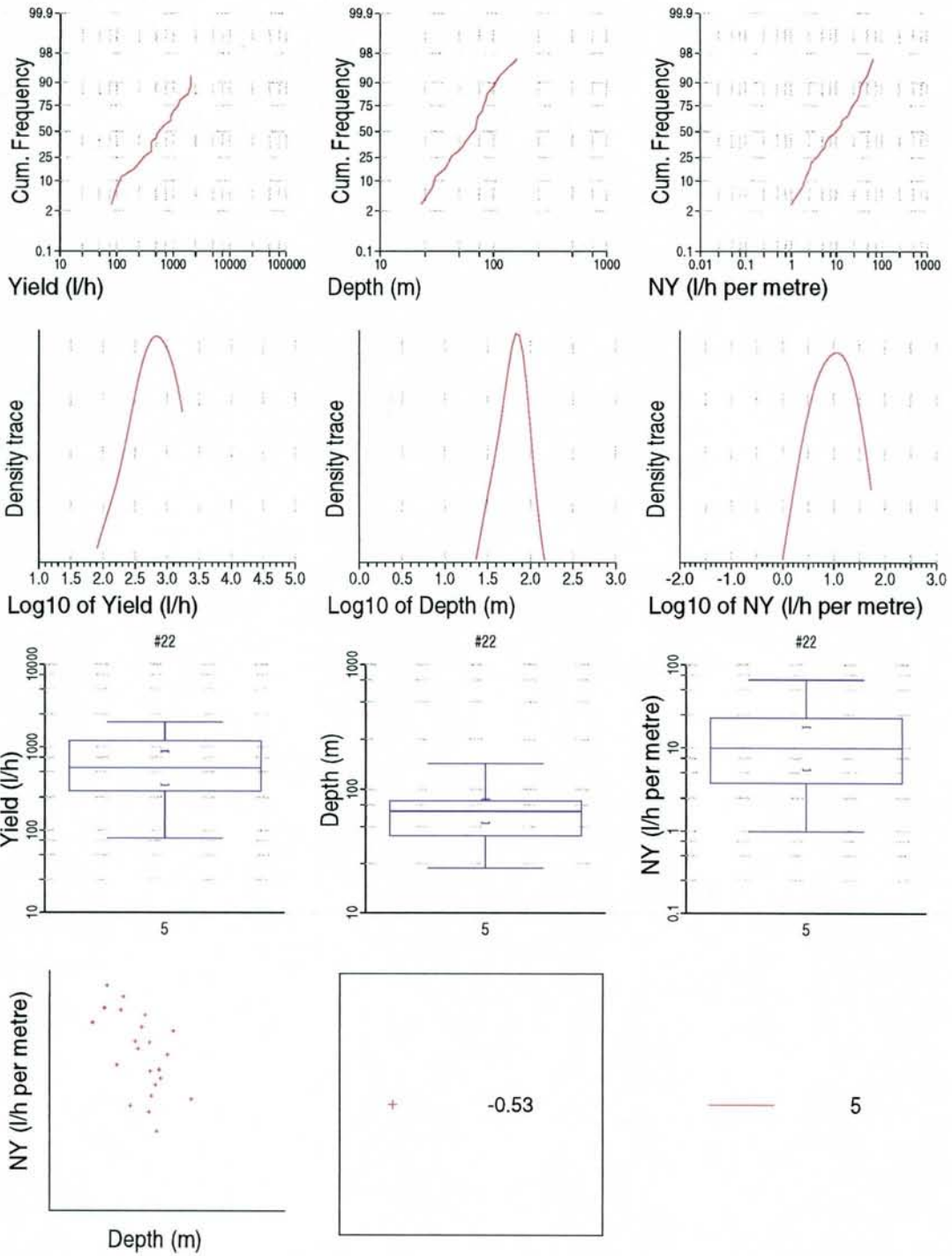
All boreholes within each sub-area



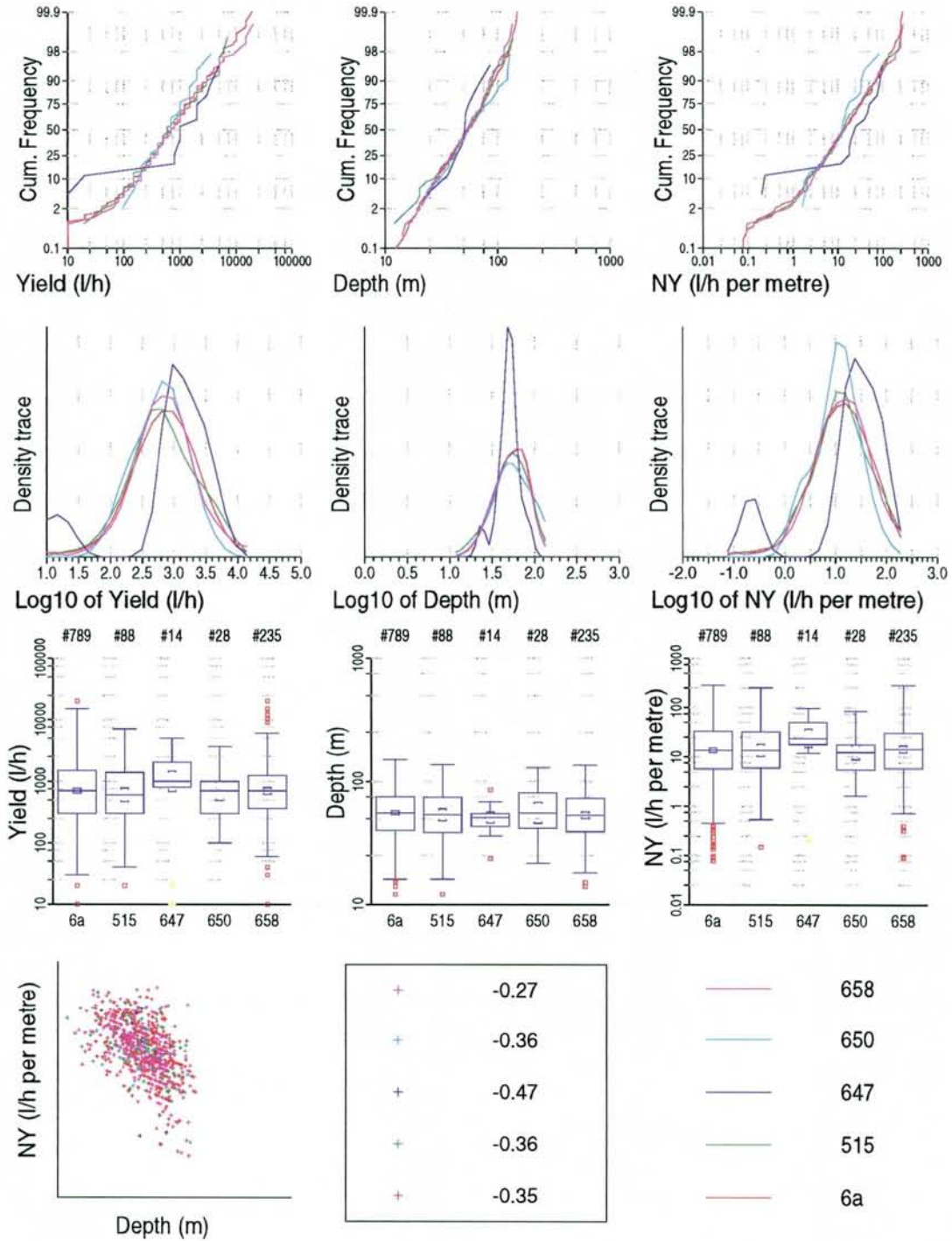
All boreholes within each sub-area



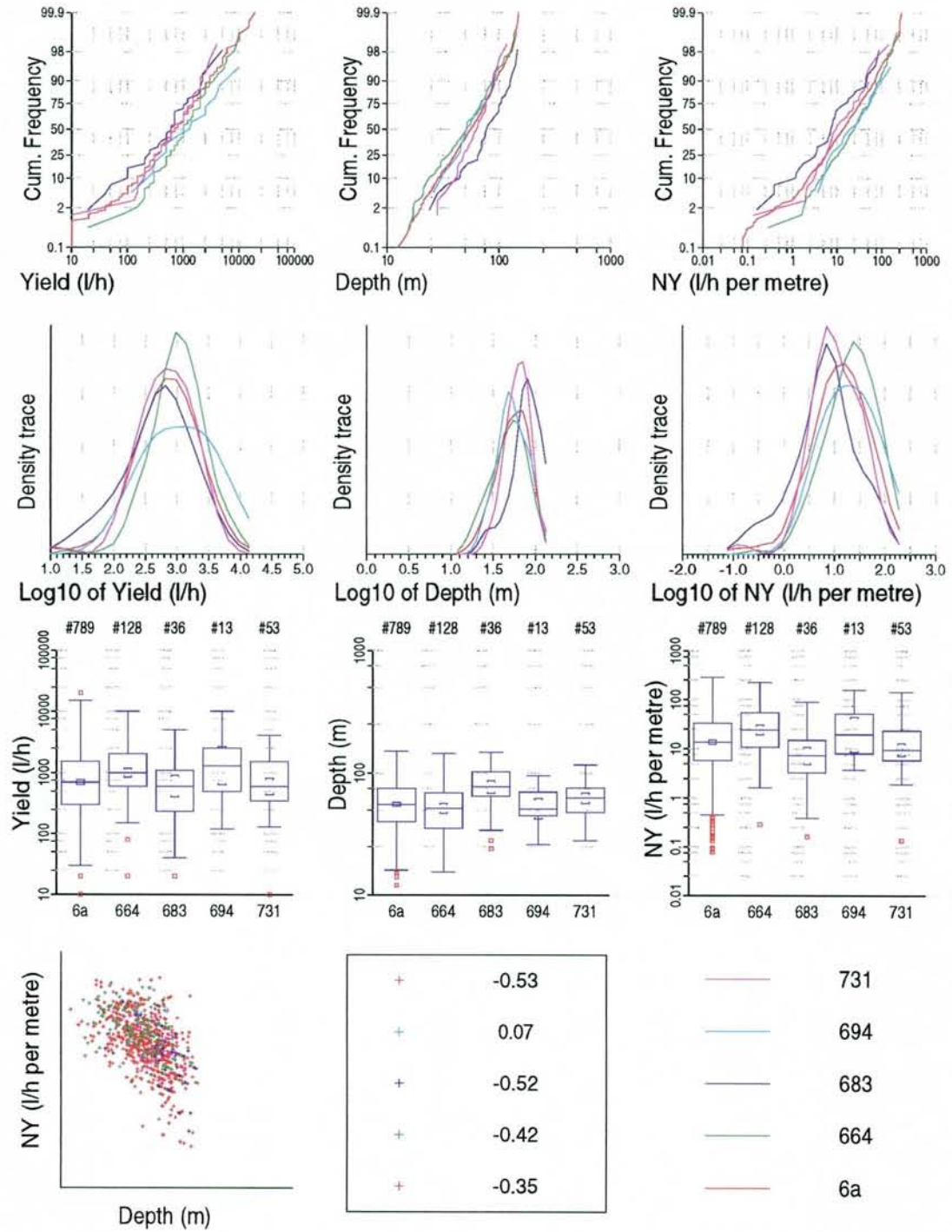
All boreholes within each sub-area



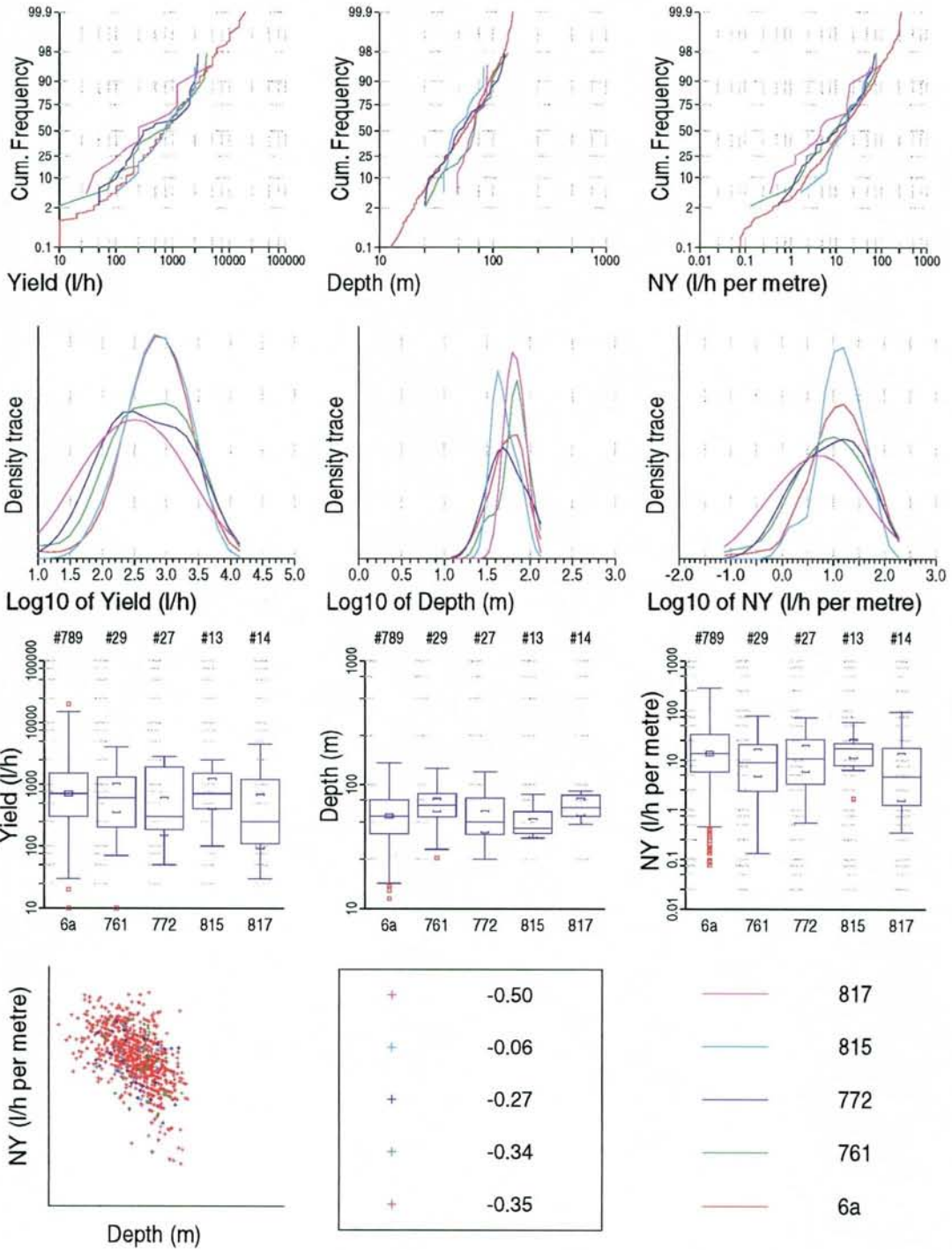
All boreholes within each sub-area



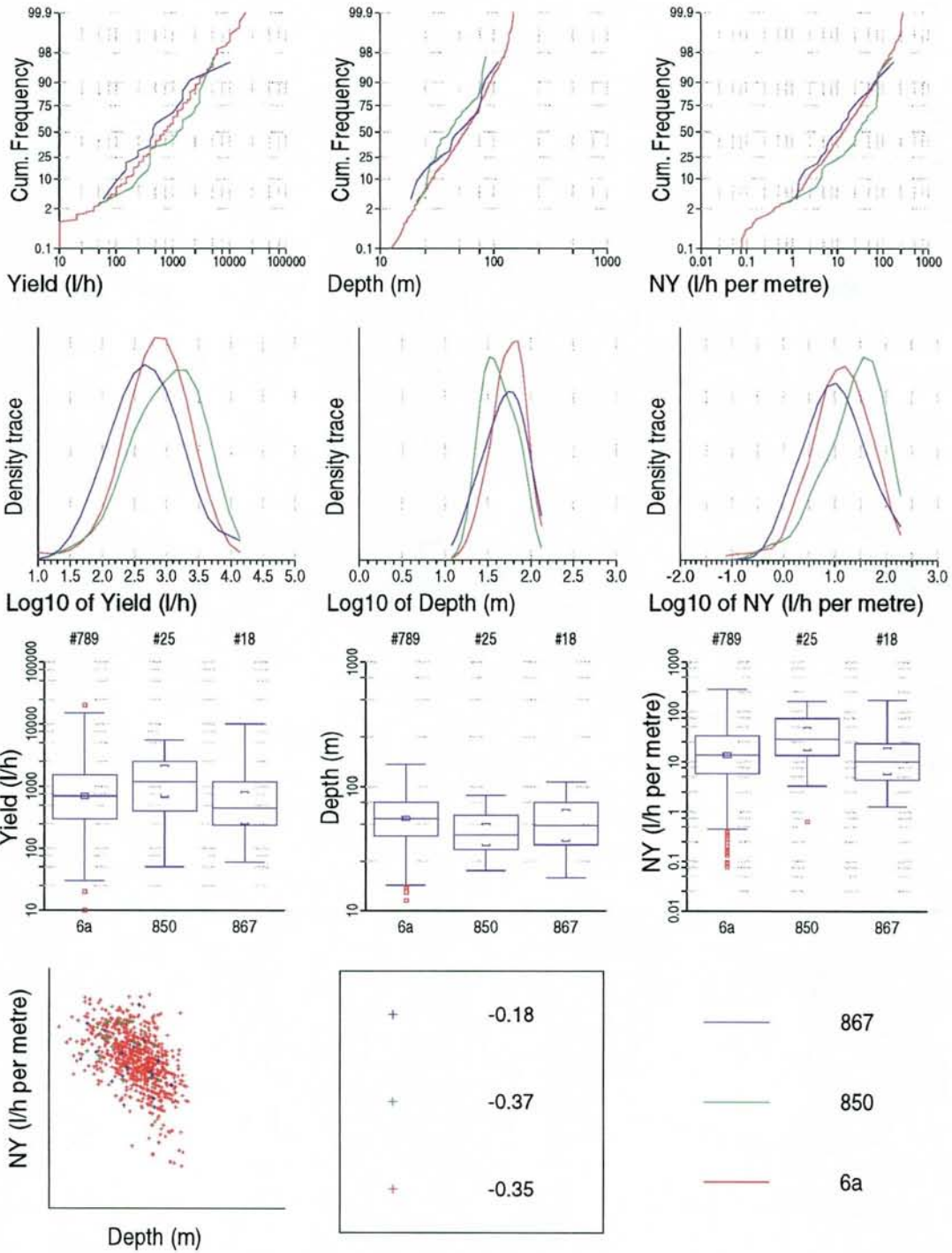
All boreholes within each sub-area



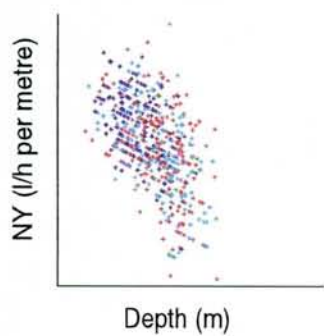
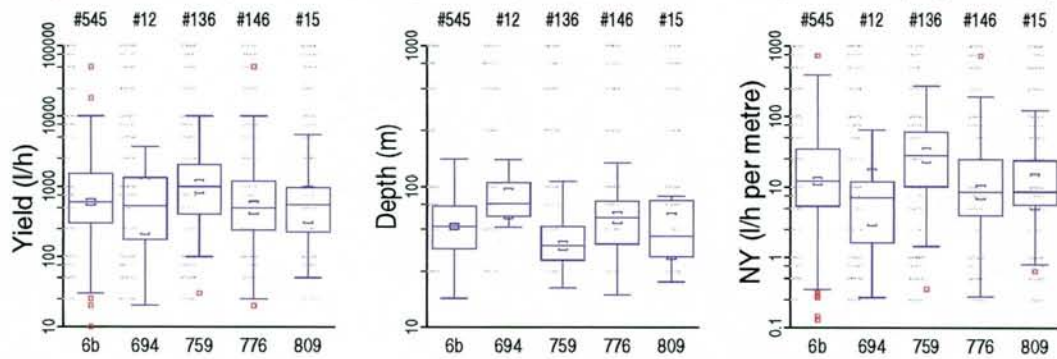
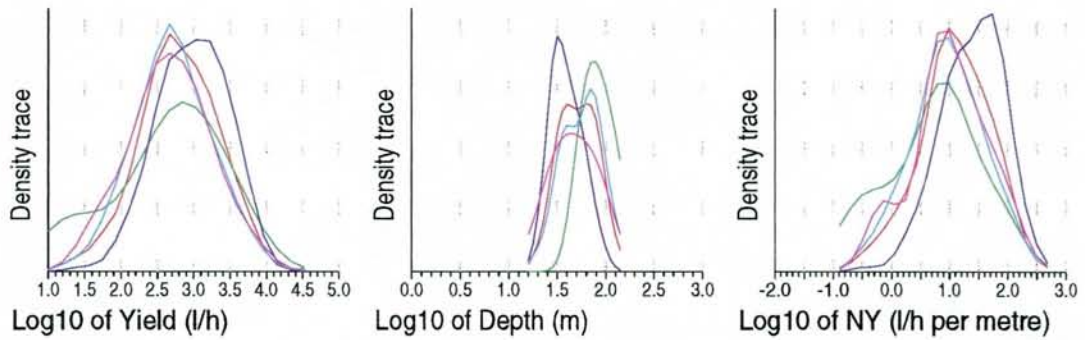
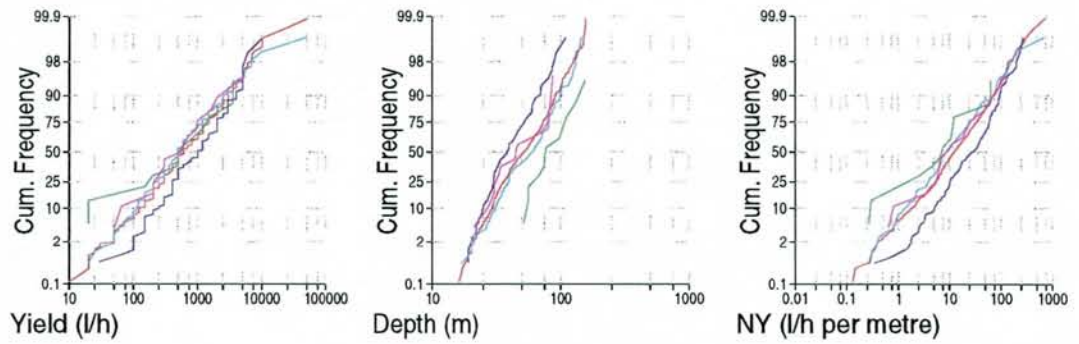
All boreholes within each sub-area



All boreholes within each sub-area



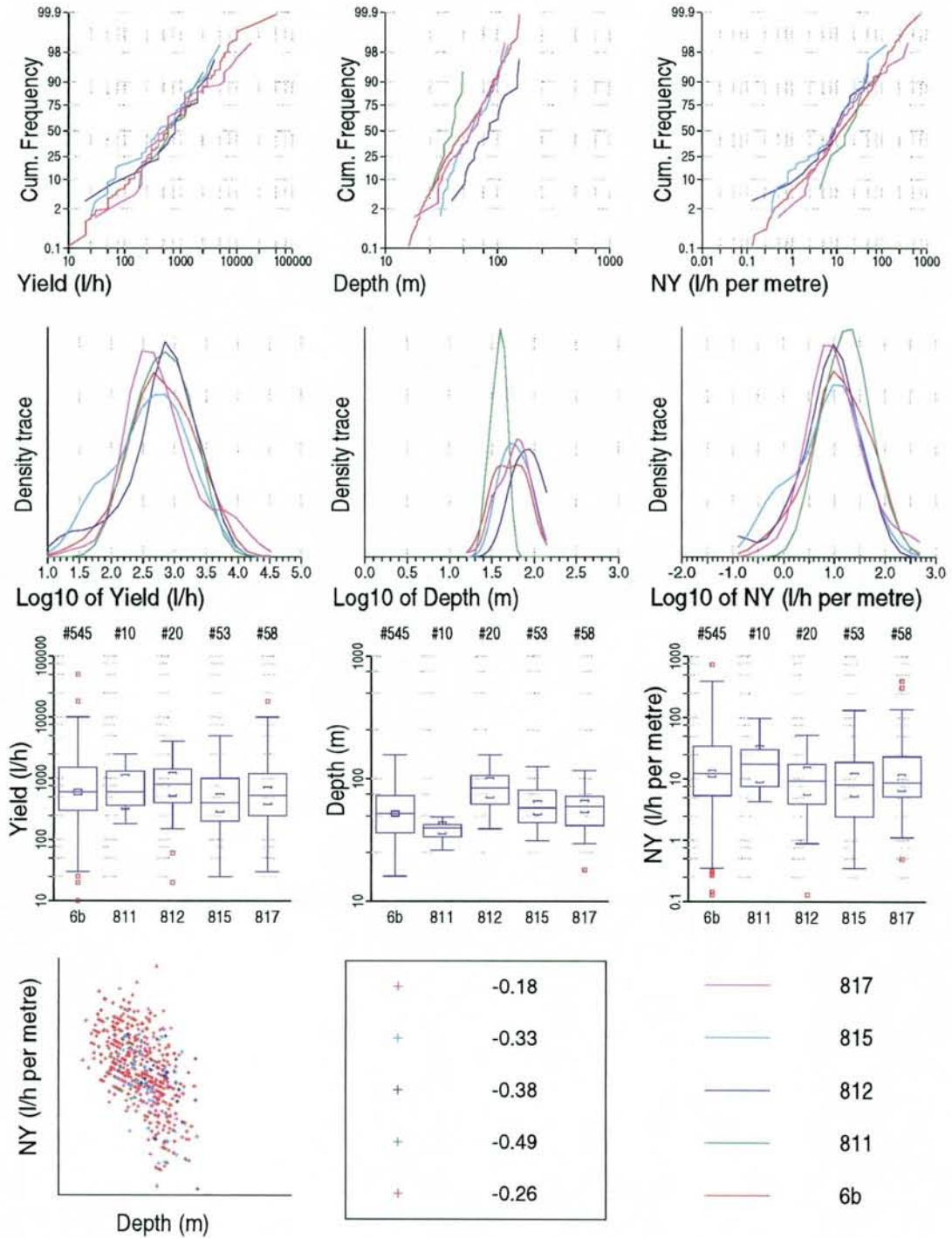
All boreholes within each sub-area



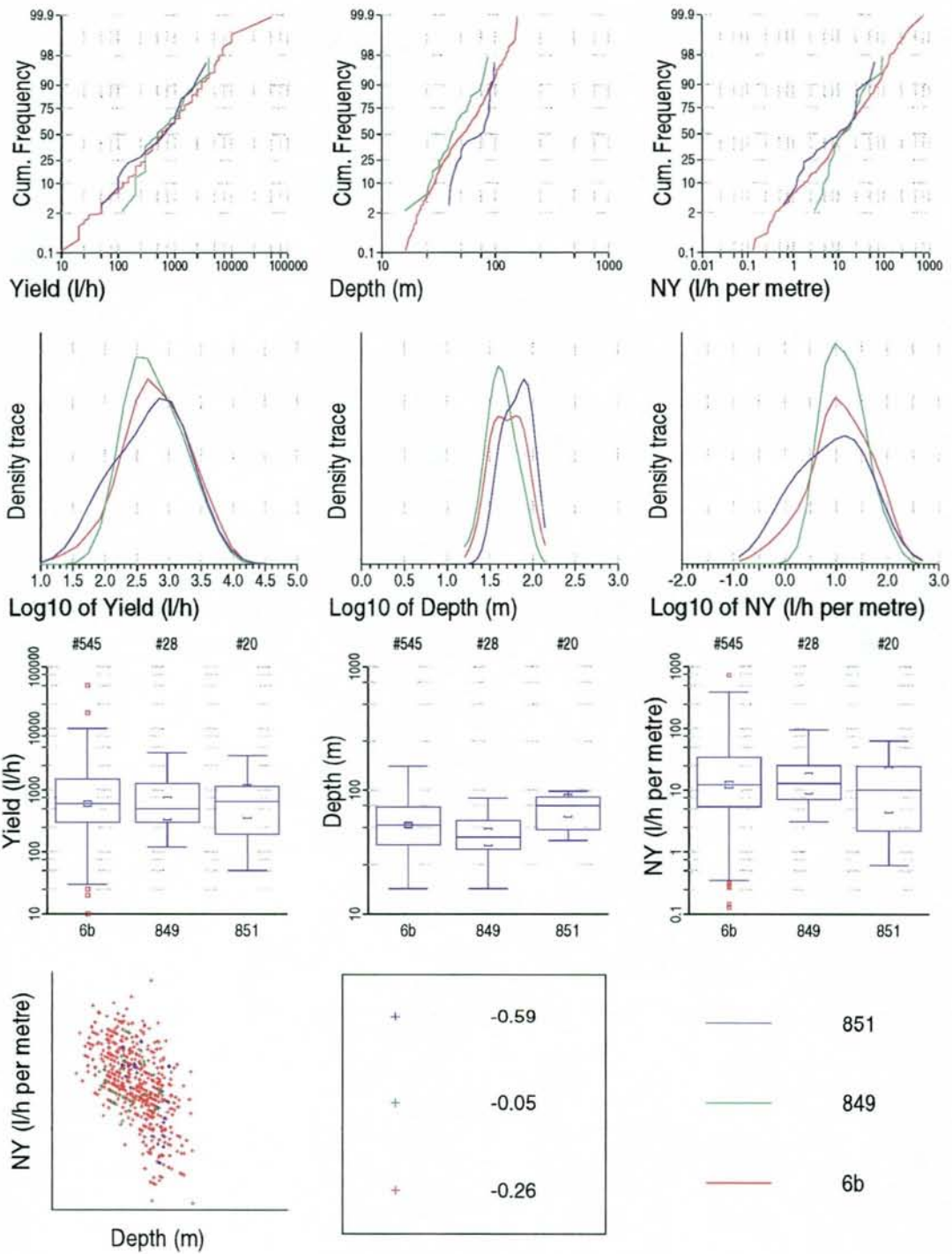
+	-0.37
+	-0.17
+	-0.32
+	-0.45
+	-0.26



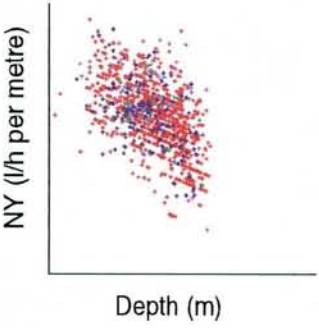
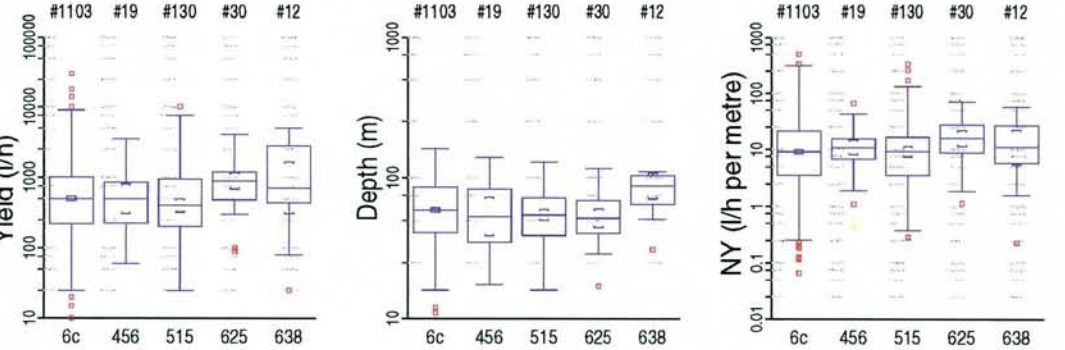
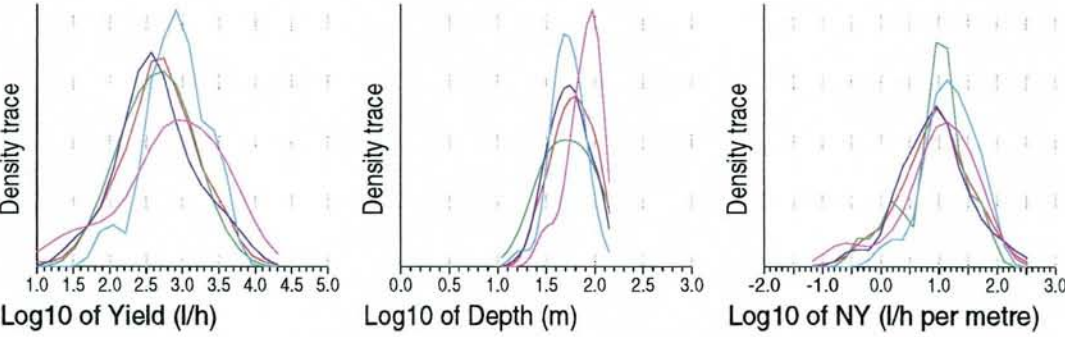
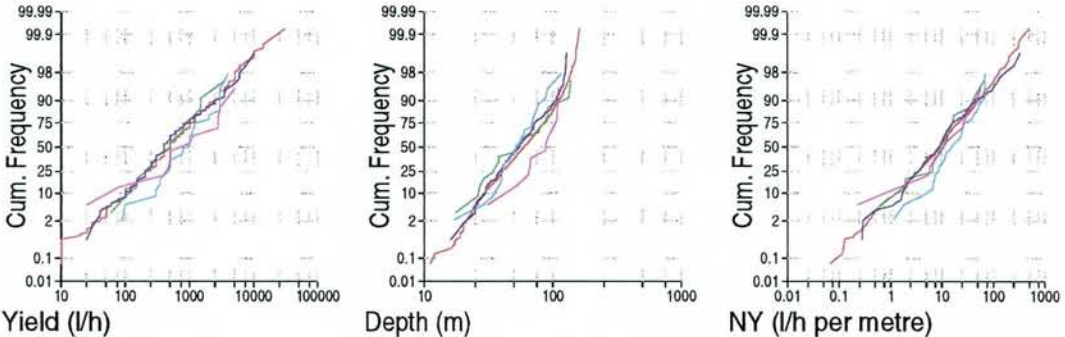
All boreholes within each sub-area



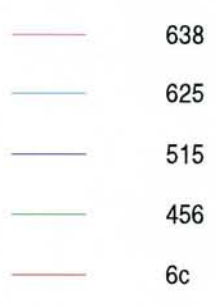
All boreholes within each sub-area



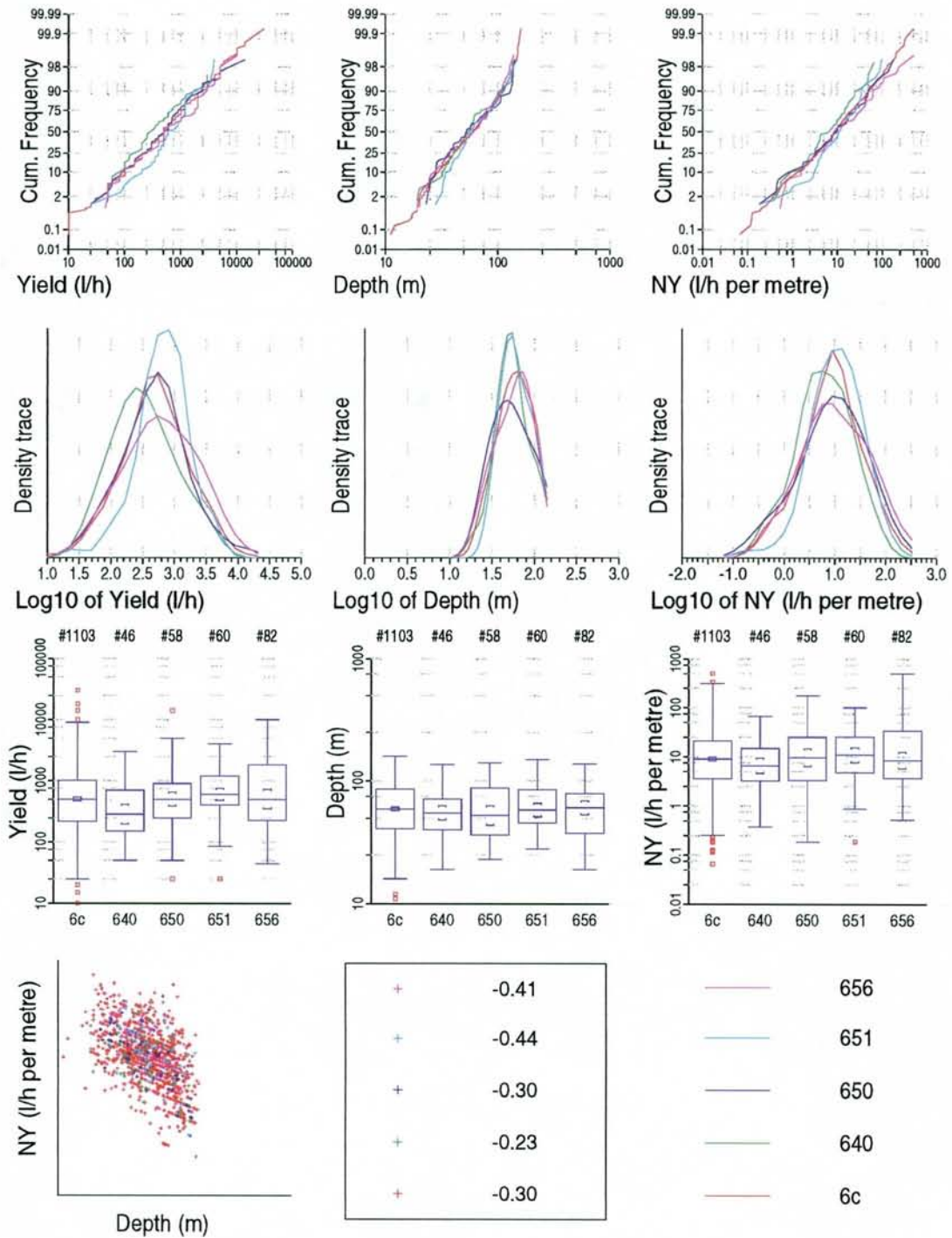
All boreholes within each sub-area



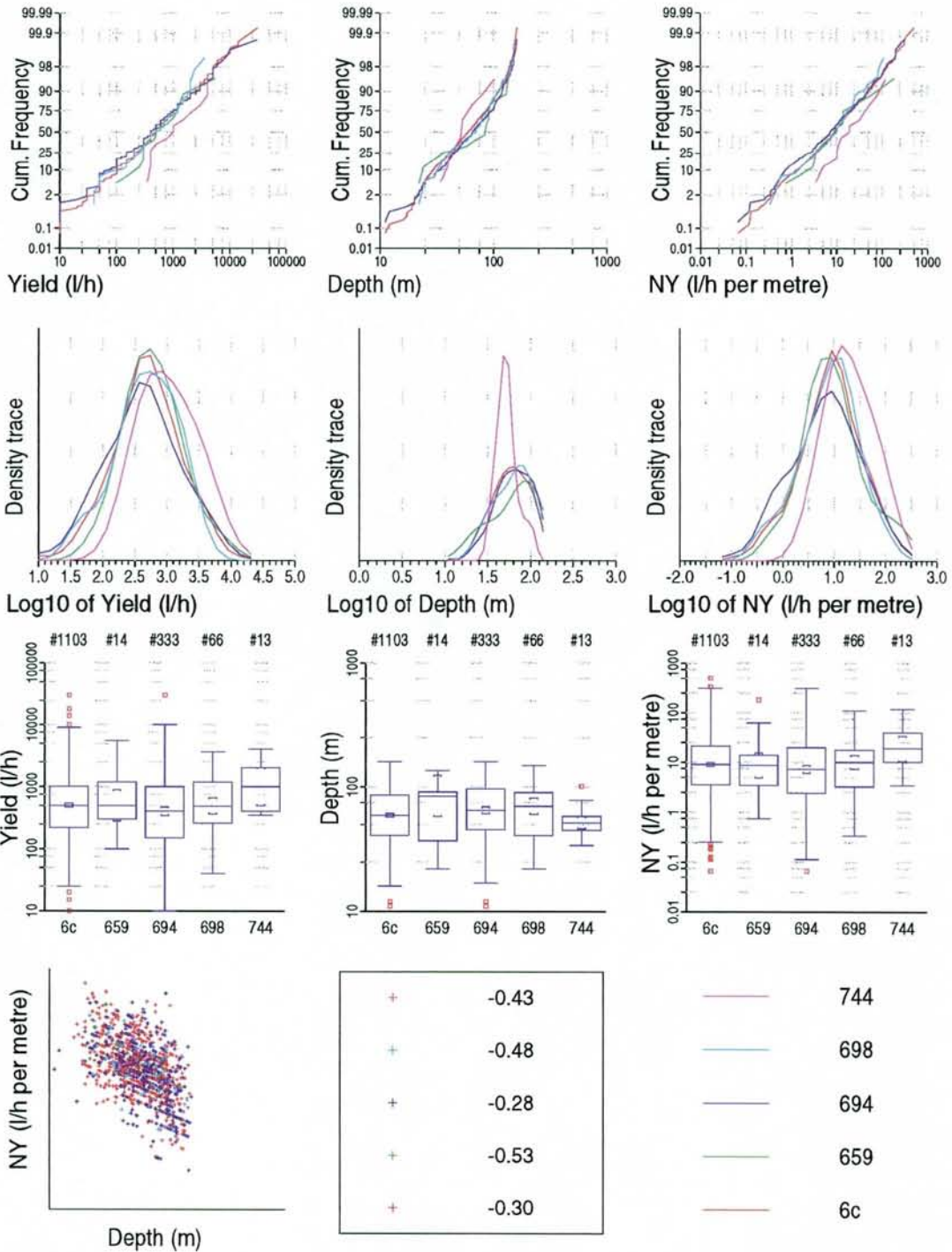
+	0.08
+	-0.29
+	-0.28
+	-0.37
+	-0.30



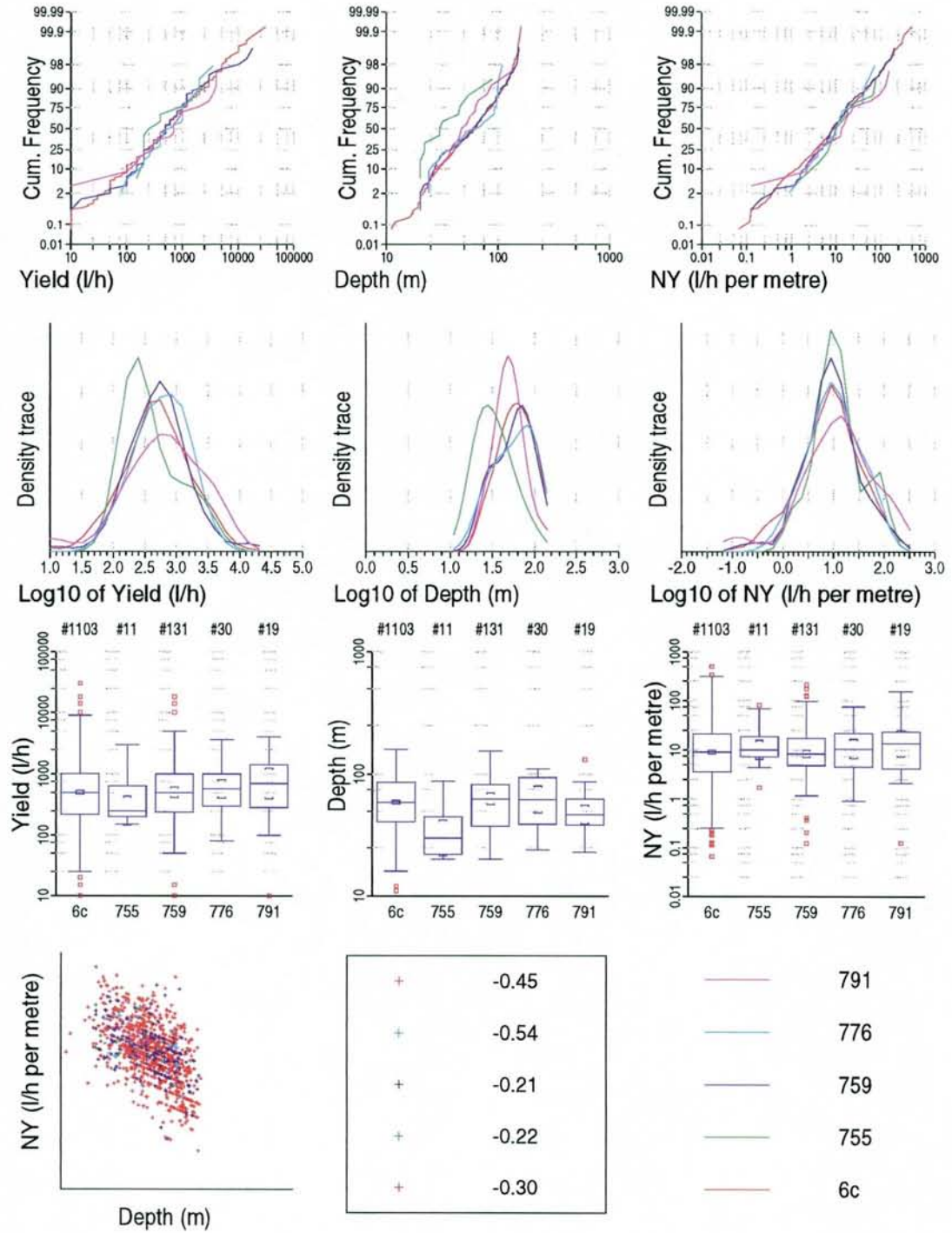
All boreholes within each sub-area



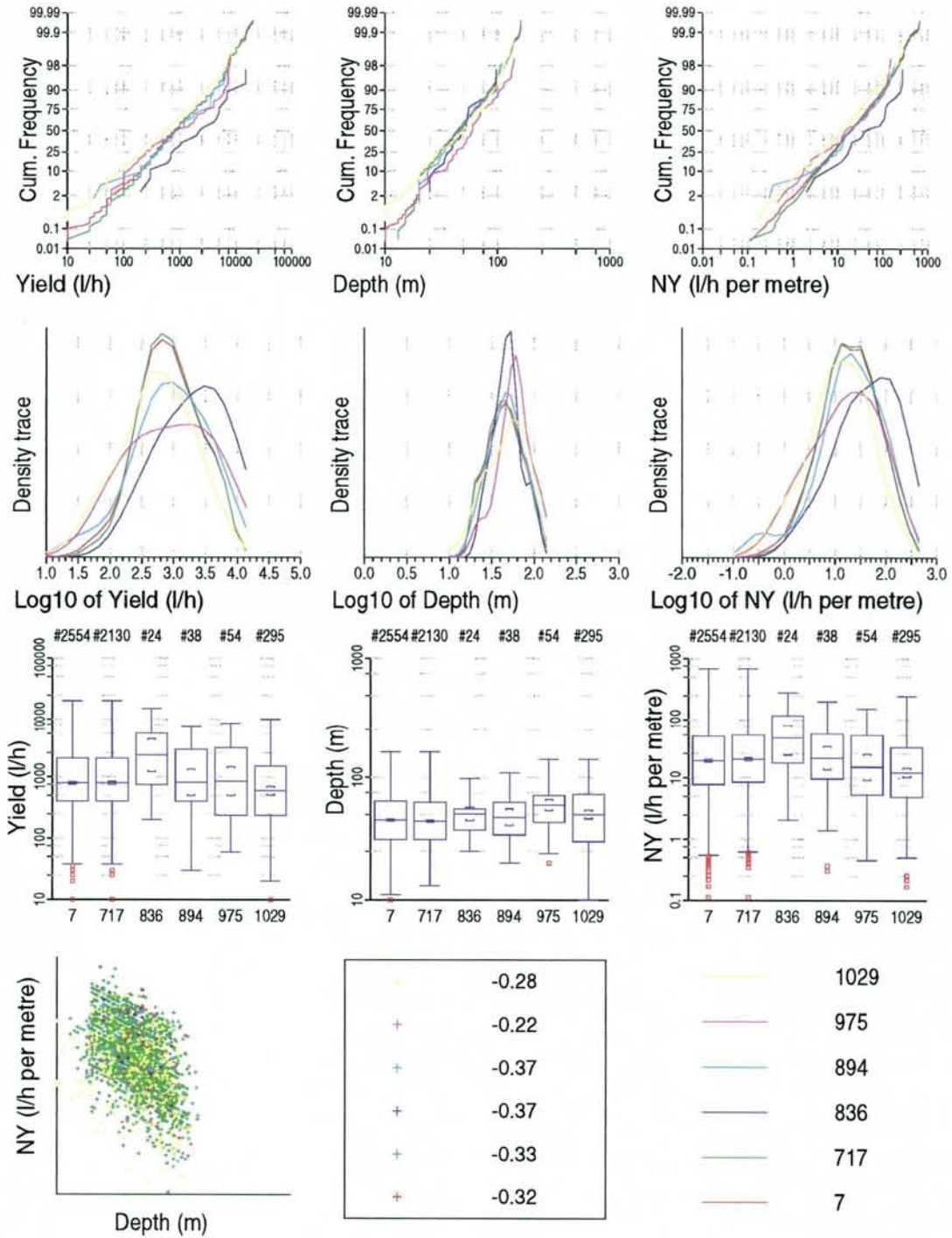
All boreholes within each sub-area



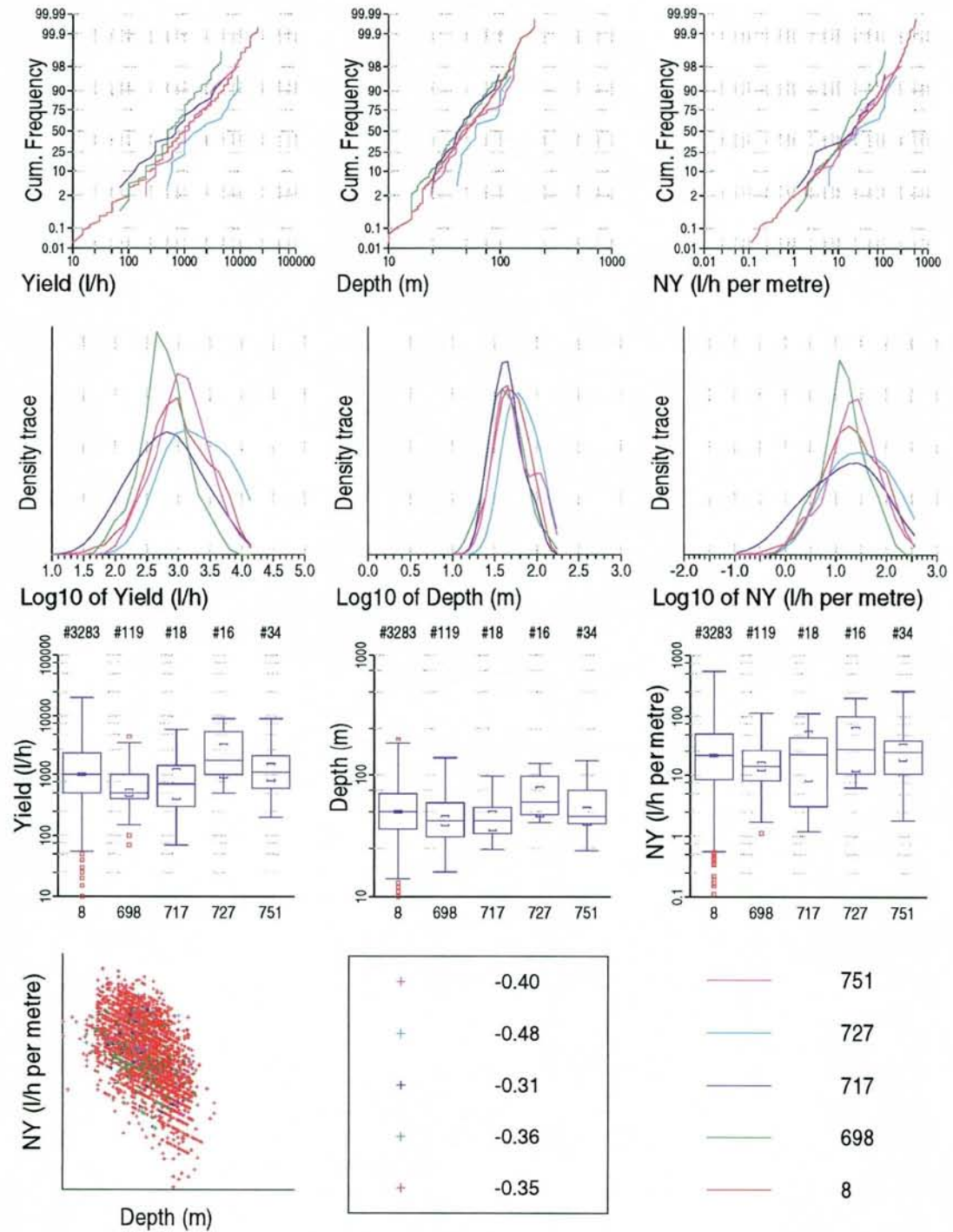
All boreholes within each sub-area



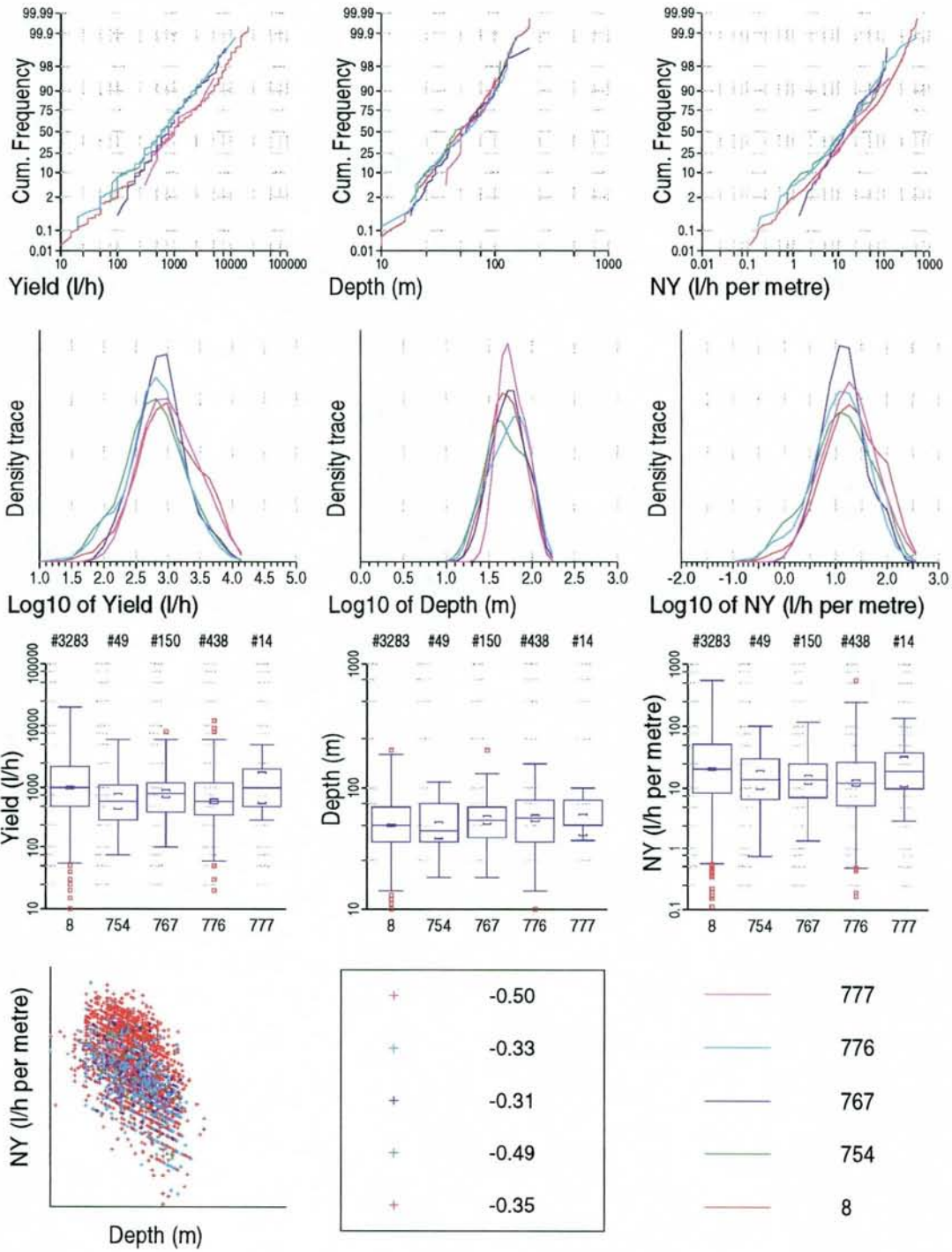
All boreholes within each sub-area



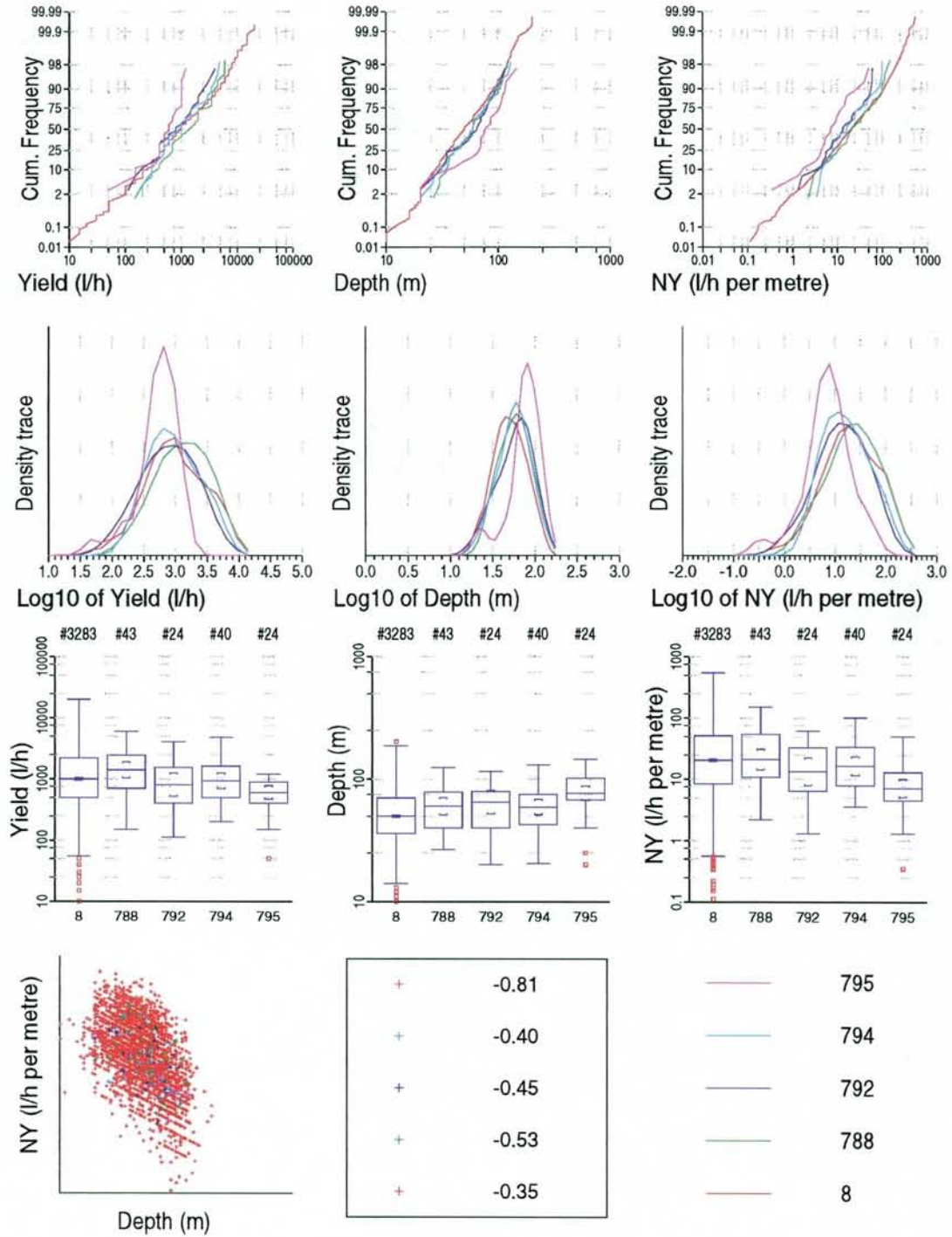
All boreholes within each sub-area



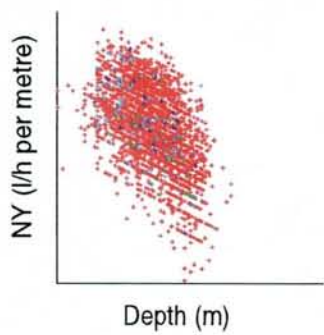
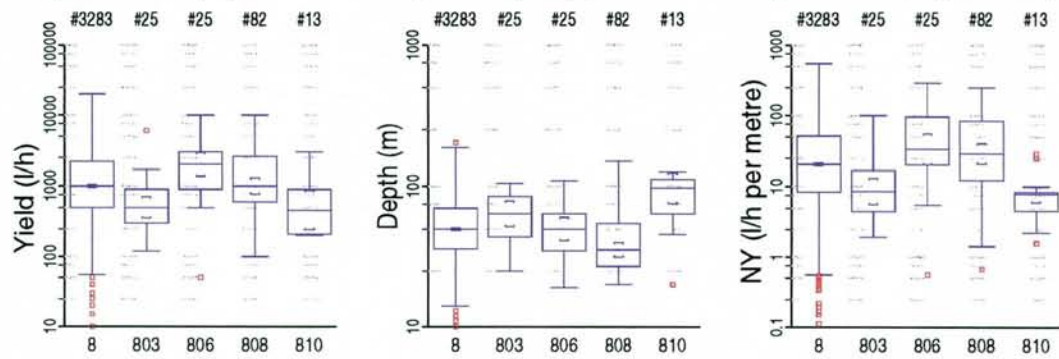
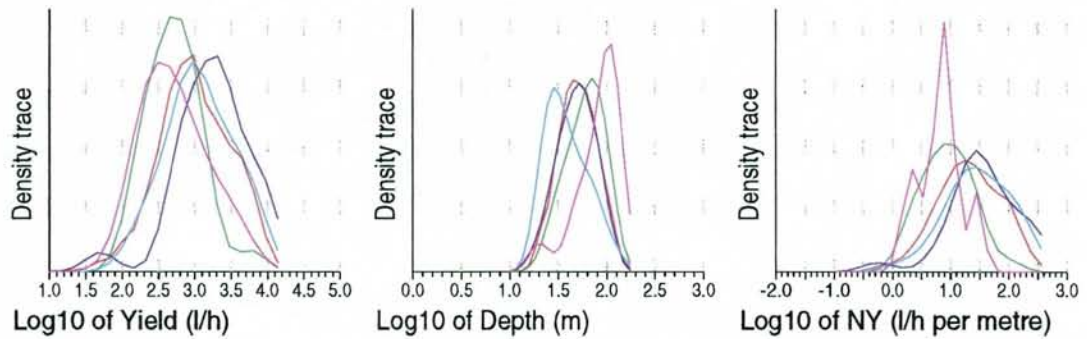
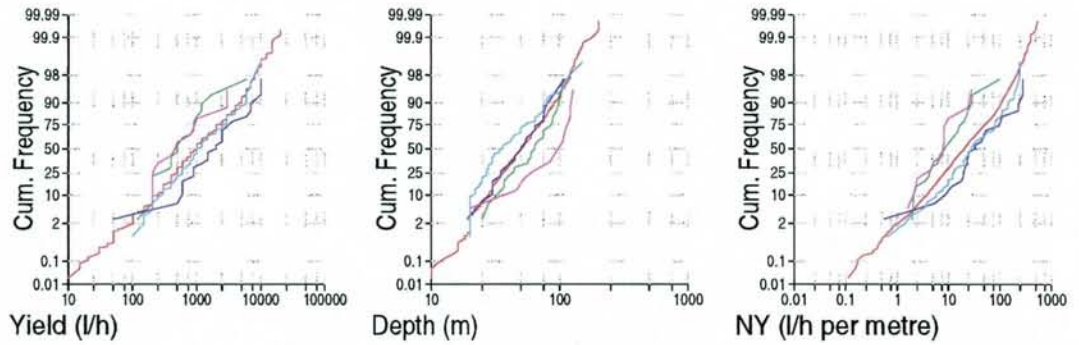
All boreholes within each sub-area



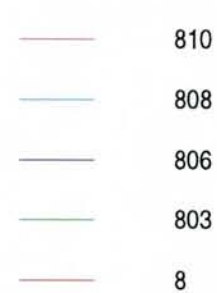
All boreholes within each sub-area



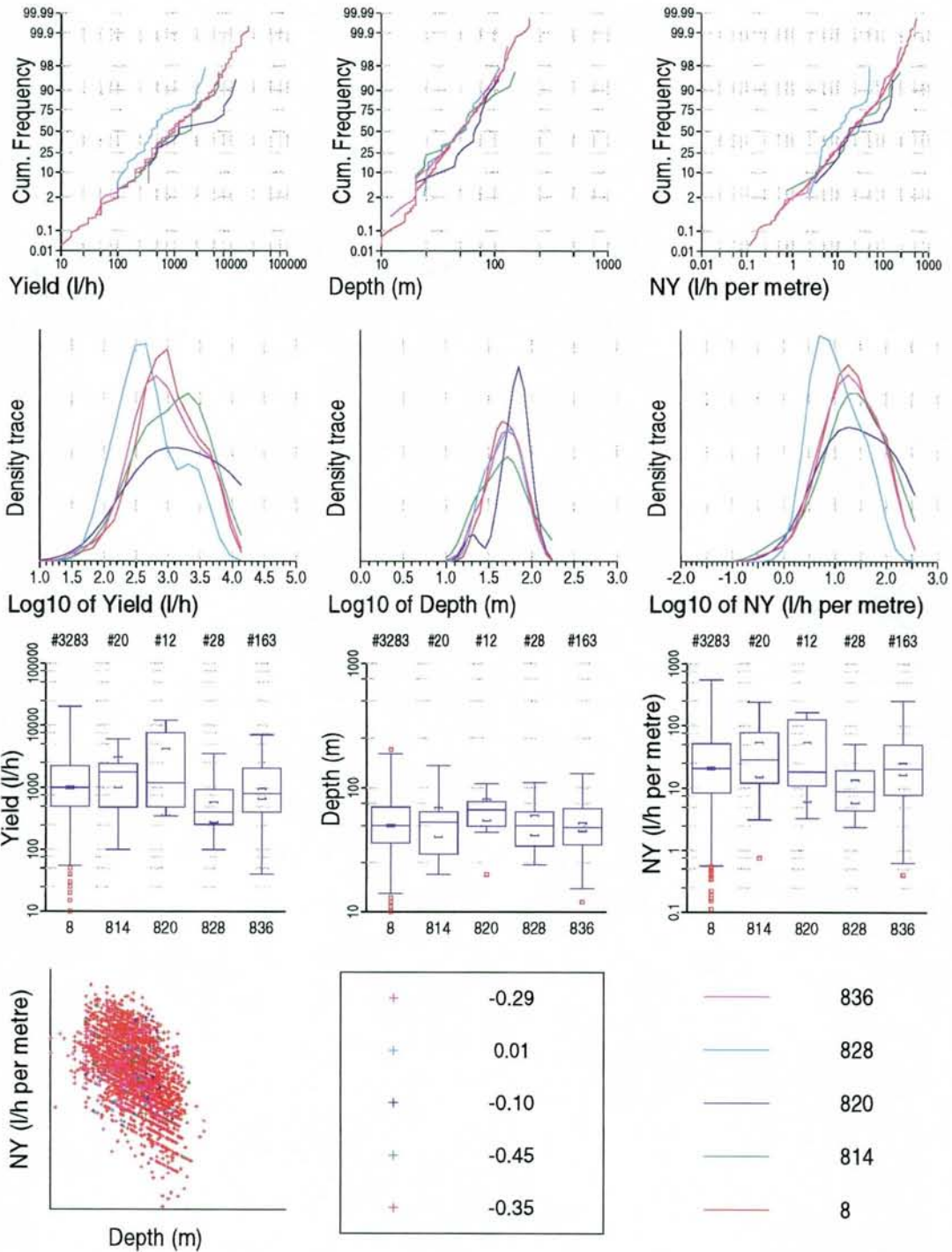
All boreholes within each sub-area



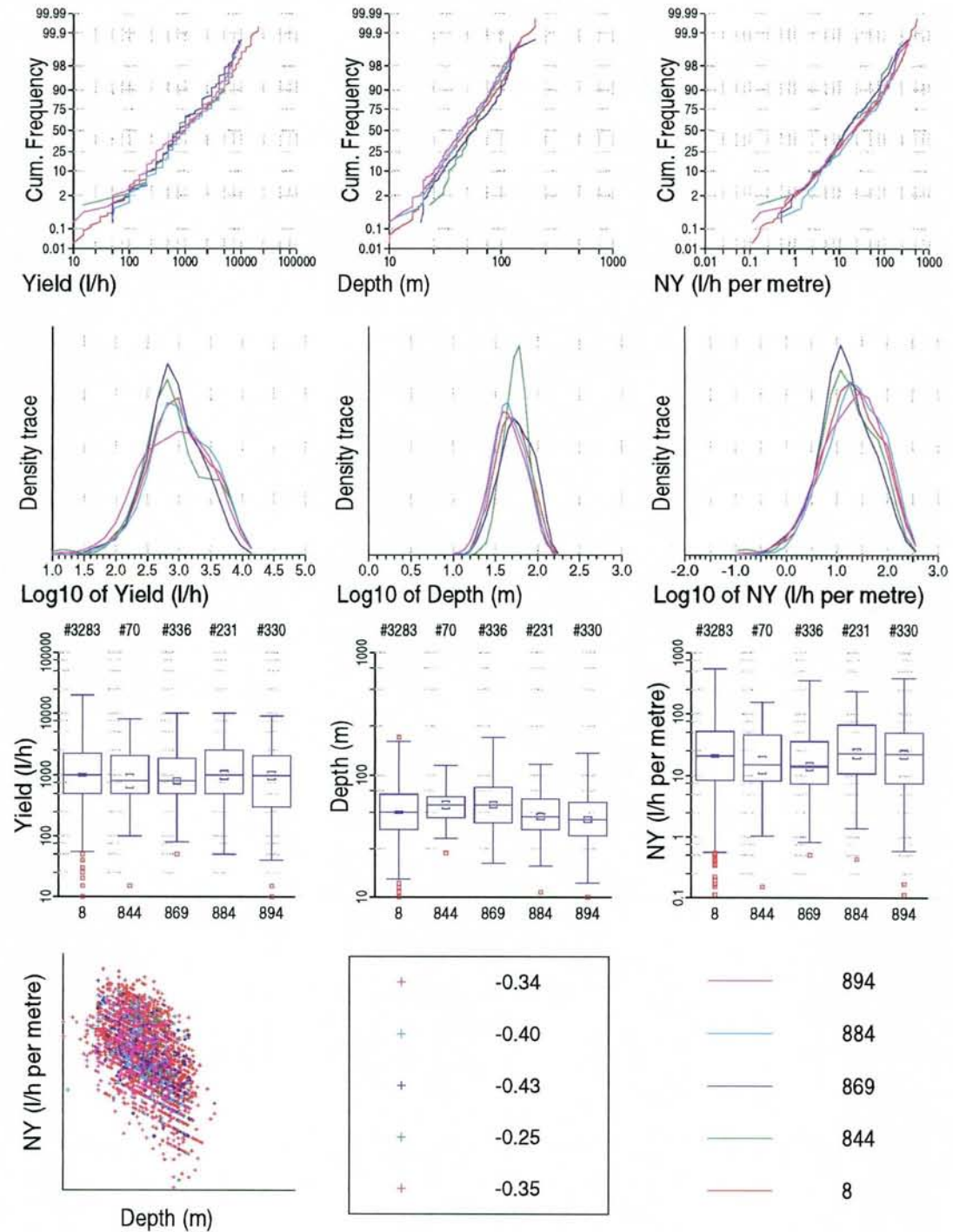
+	0.18
+	-0.37
+	-0.53
+	-0.28
+	-0.35



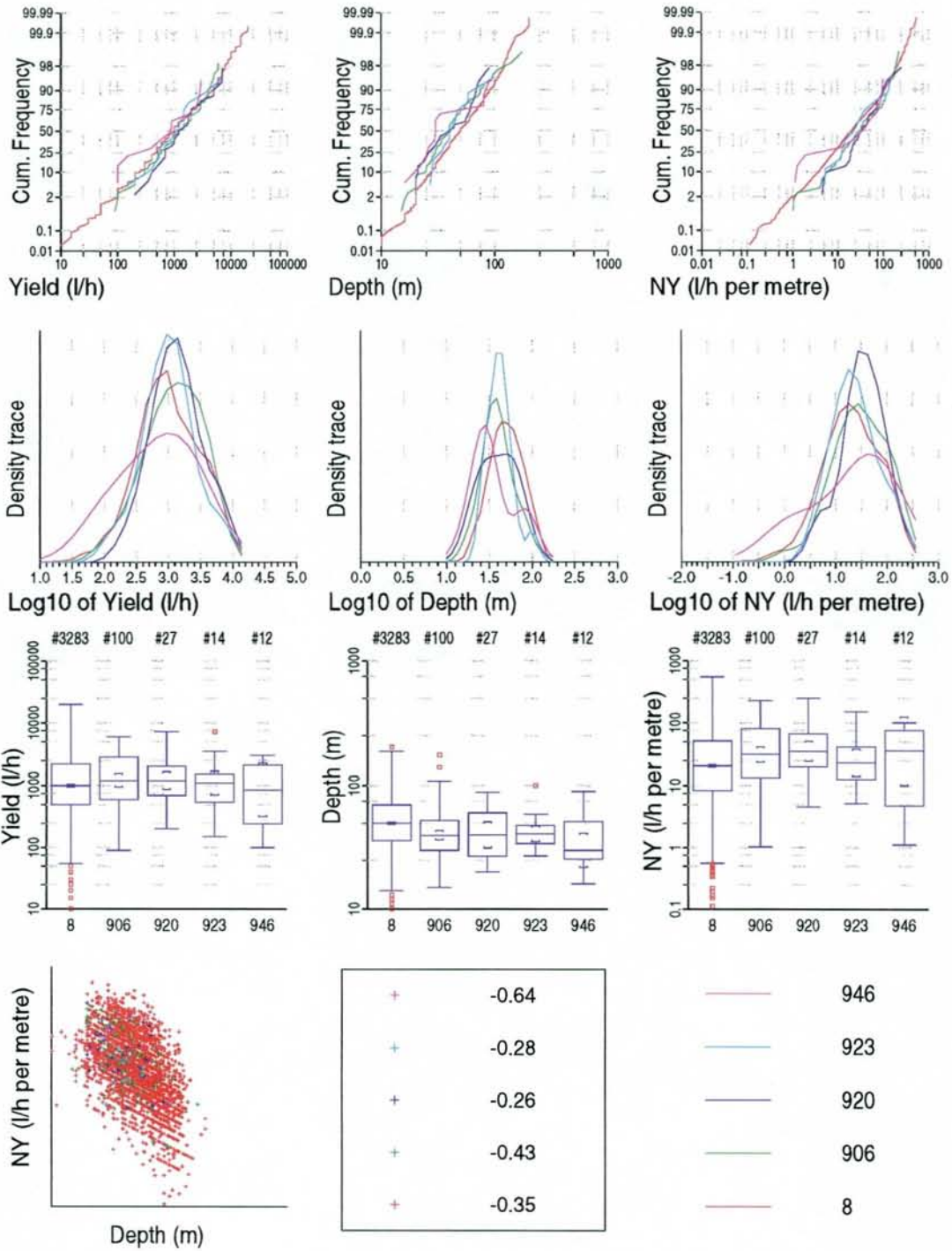
All boreholes within each sub-area



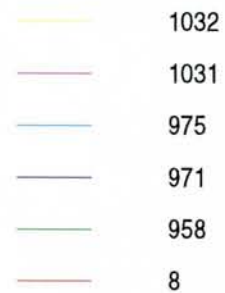
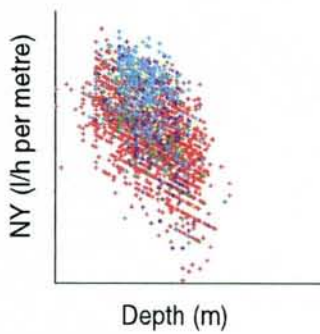
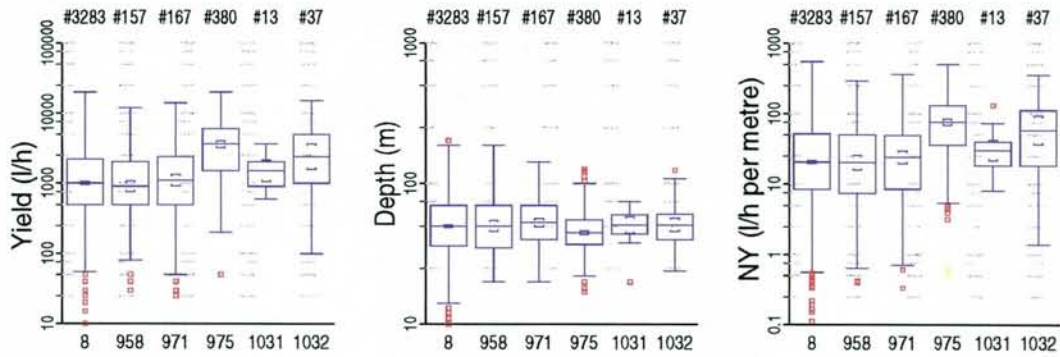
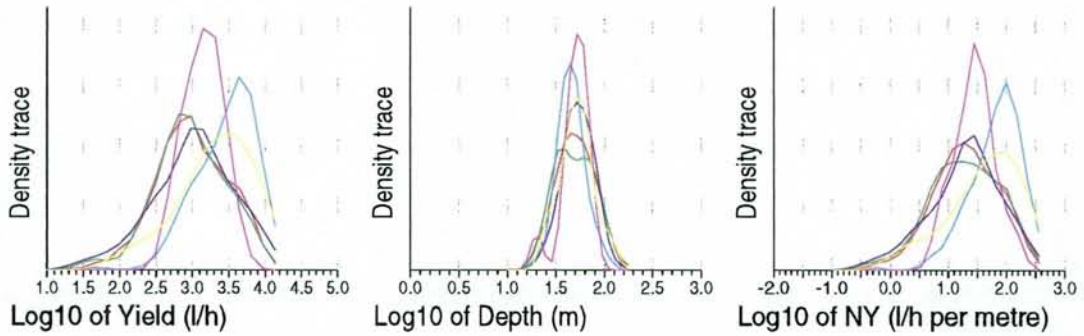
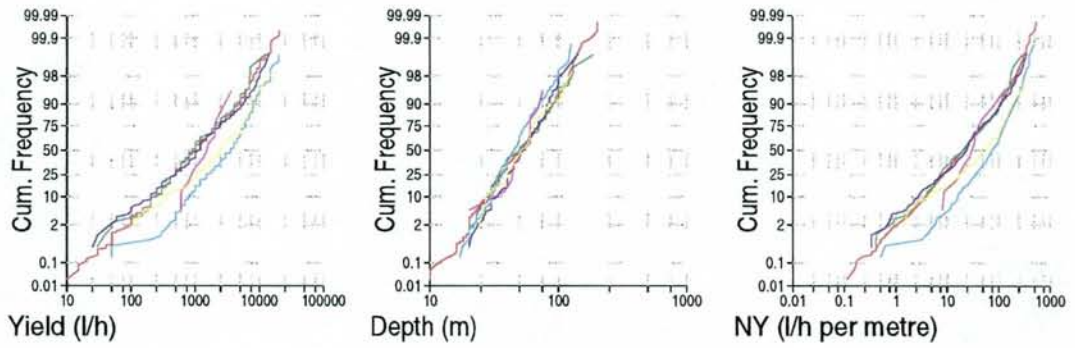
All boreholes within each sub-area



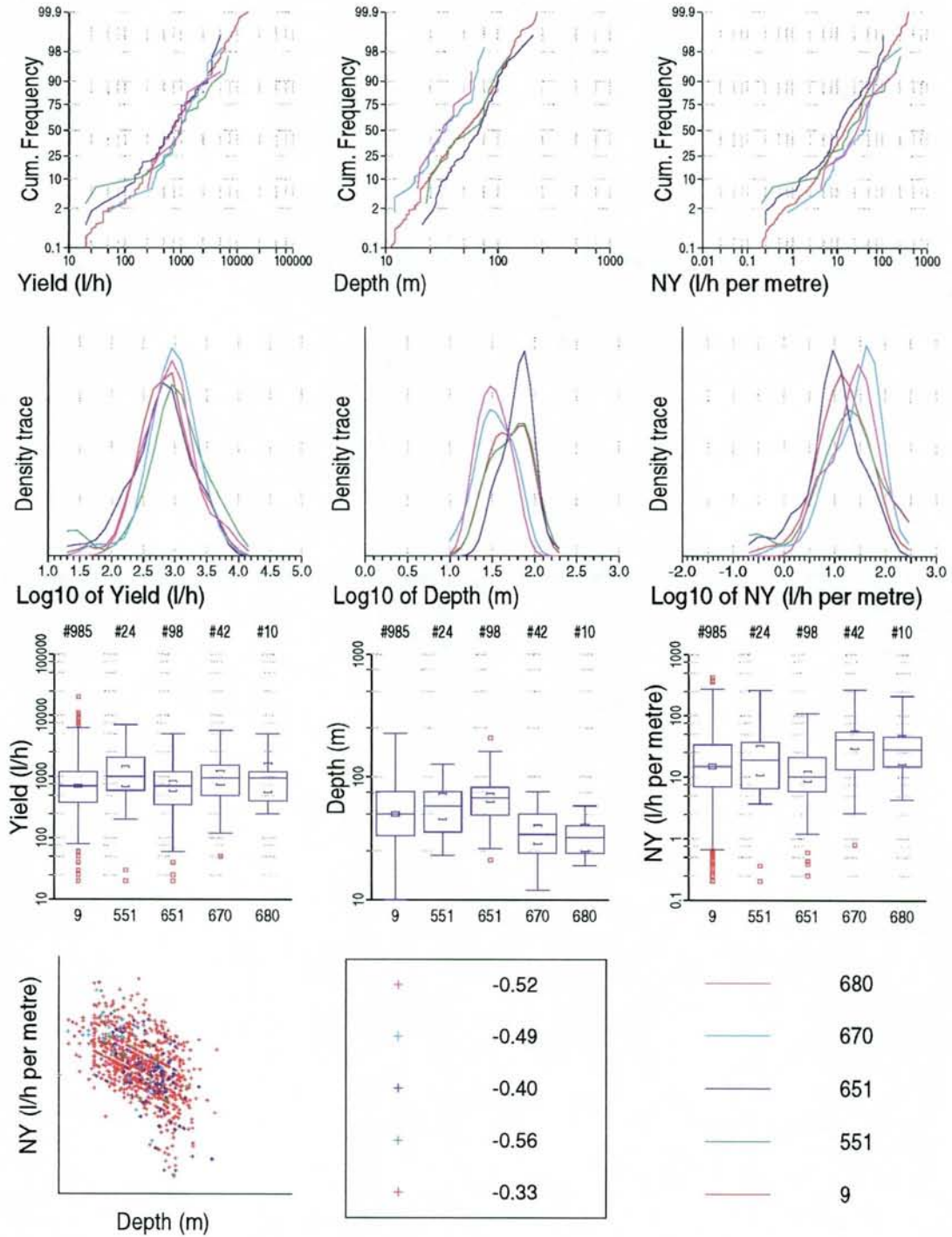
All boreholes within each sub-area



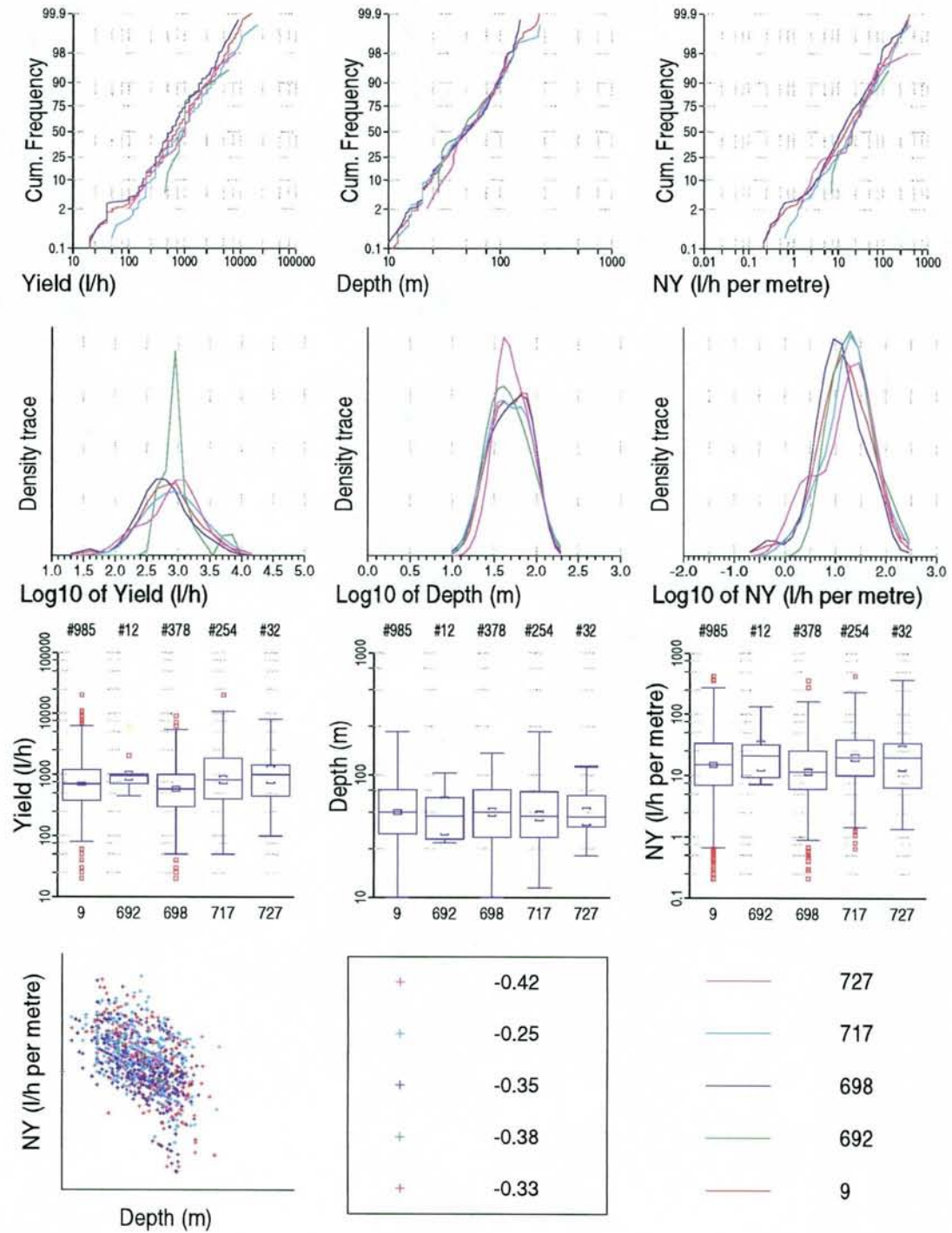
All boreholes within each sub-area



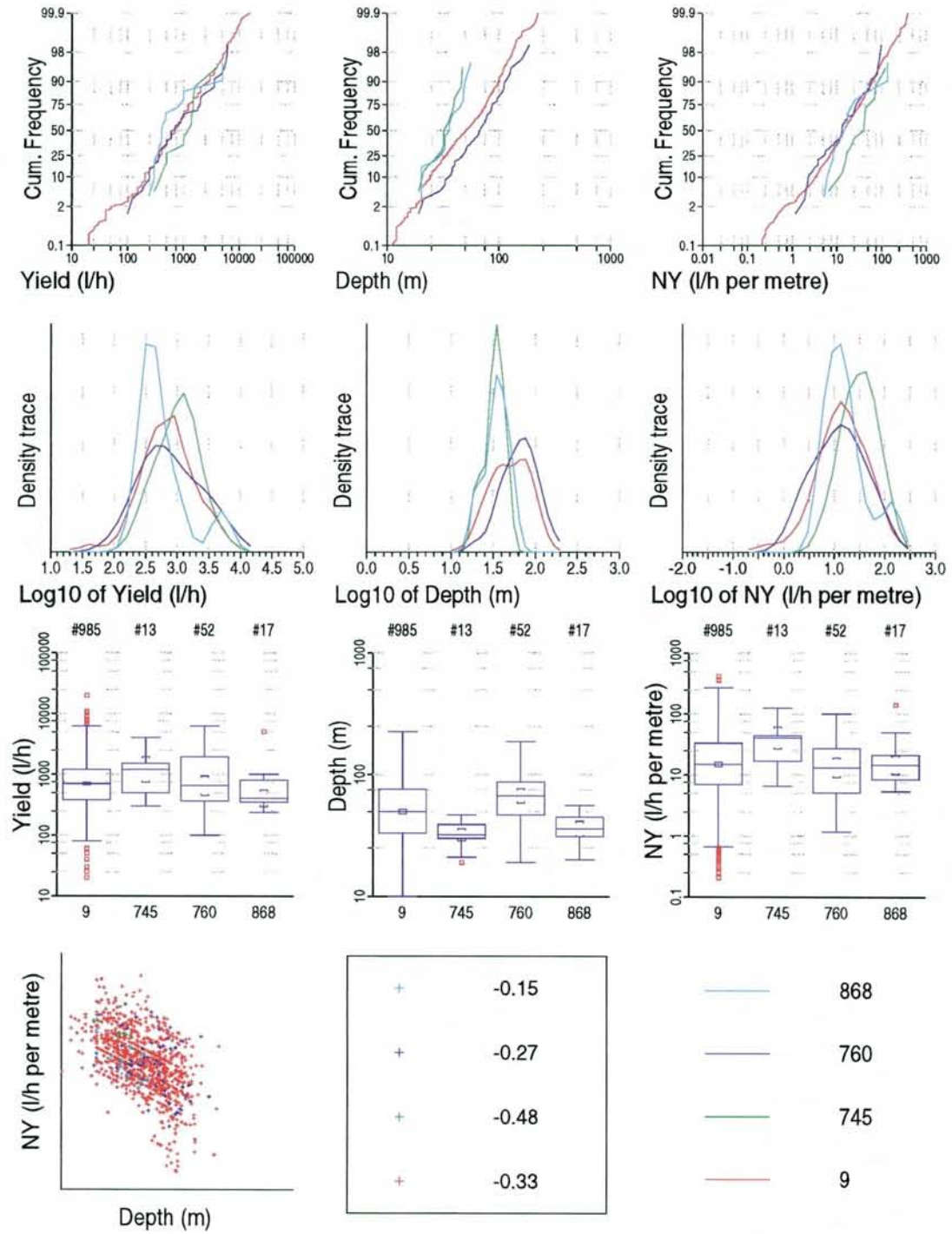
All boreholes within each sub-area



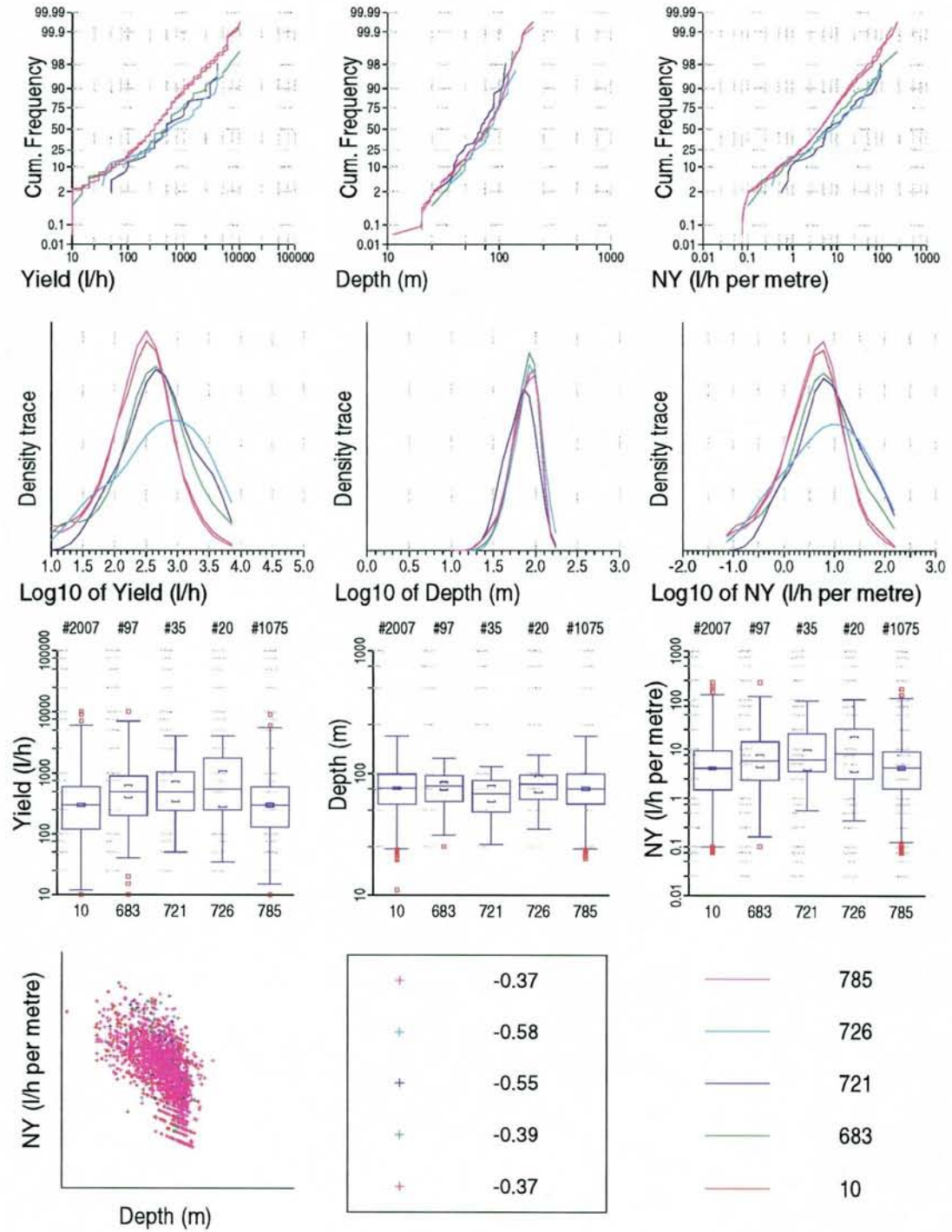
All boreholes within each sub-area



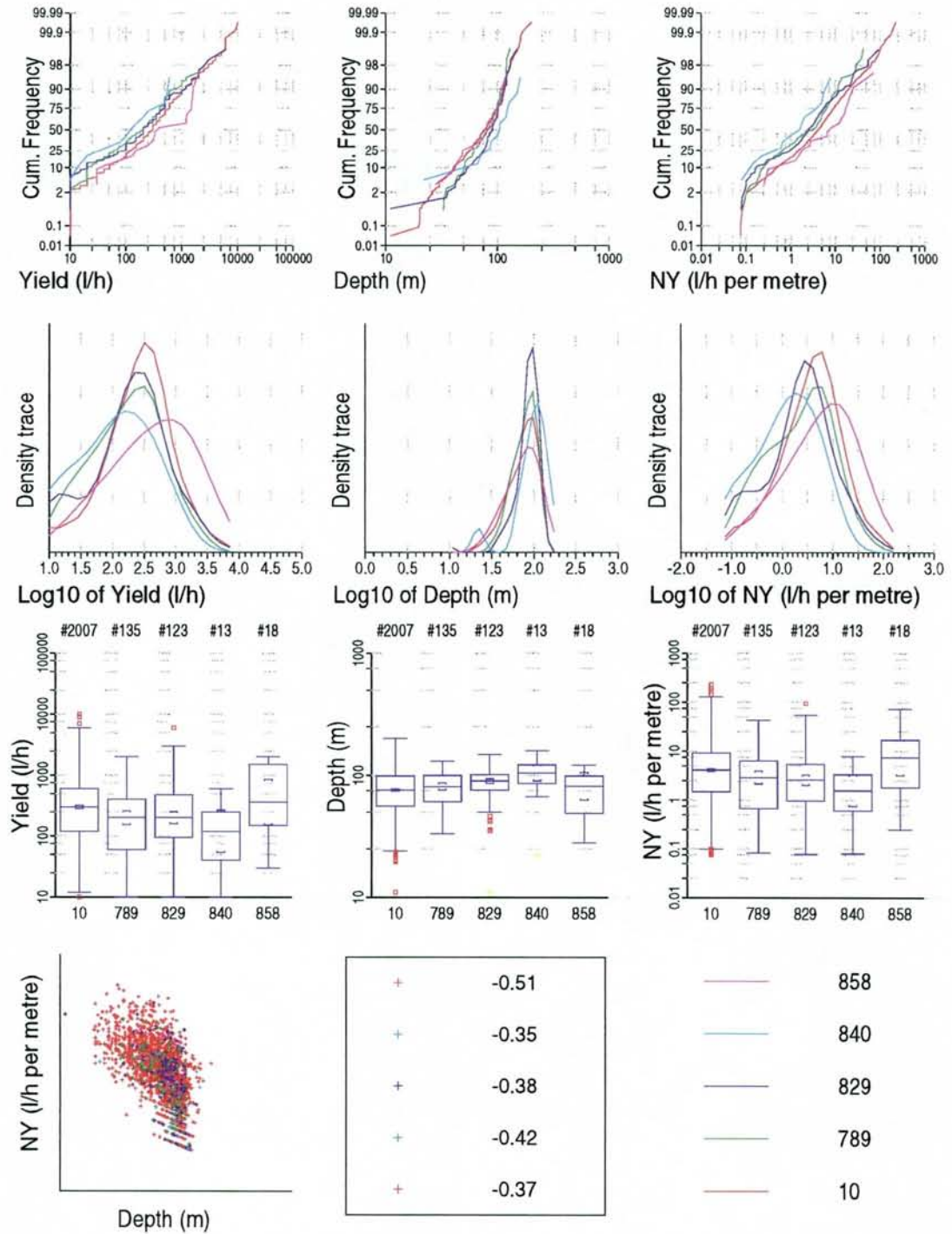
All boreholes within each sub-area



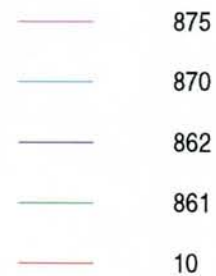
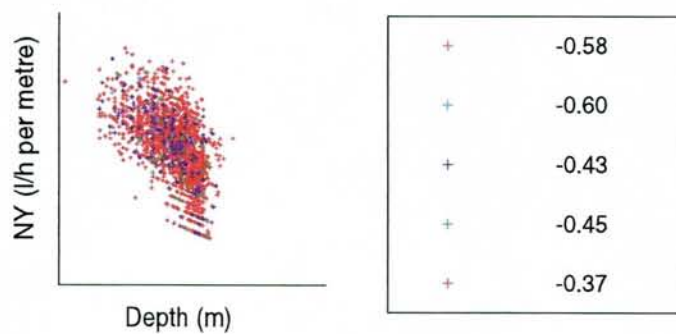
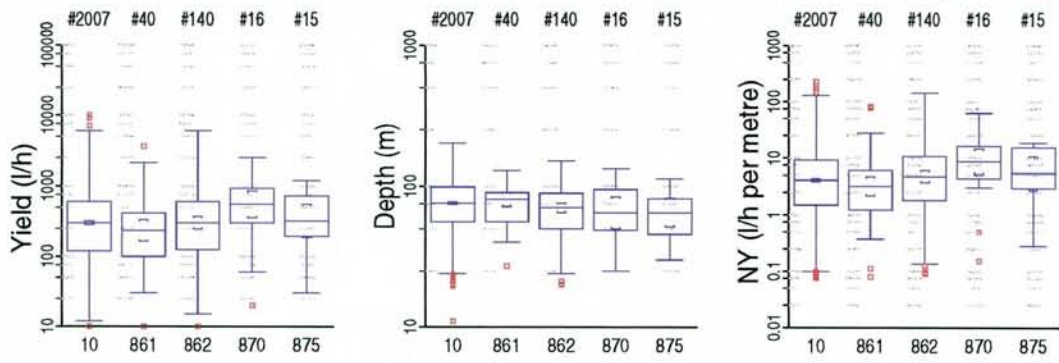
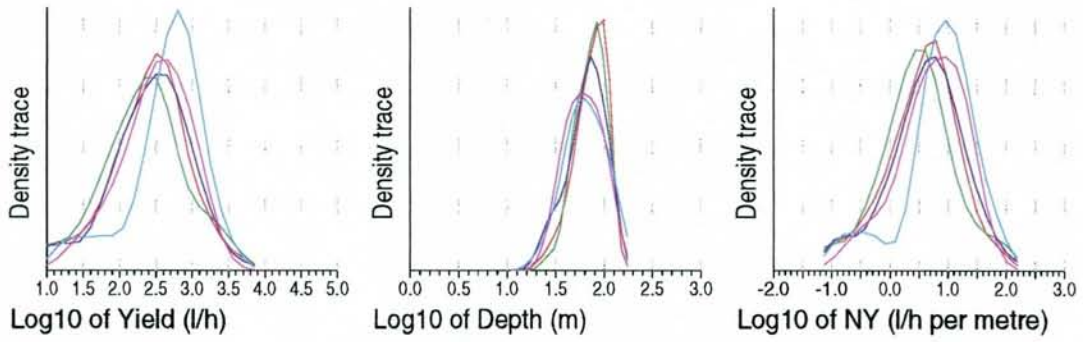
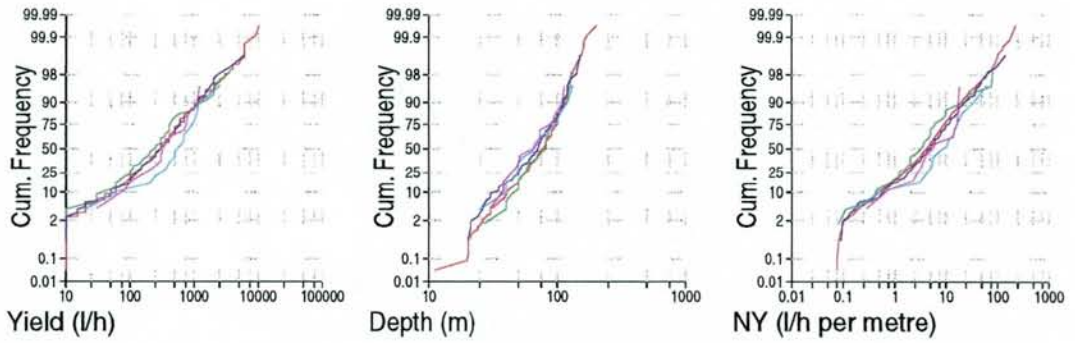
All boreholes within each sub-area



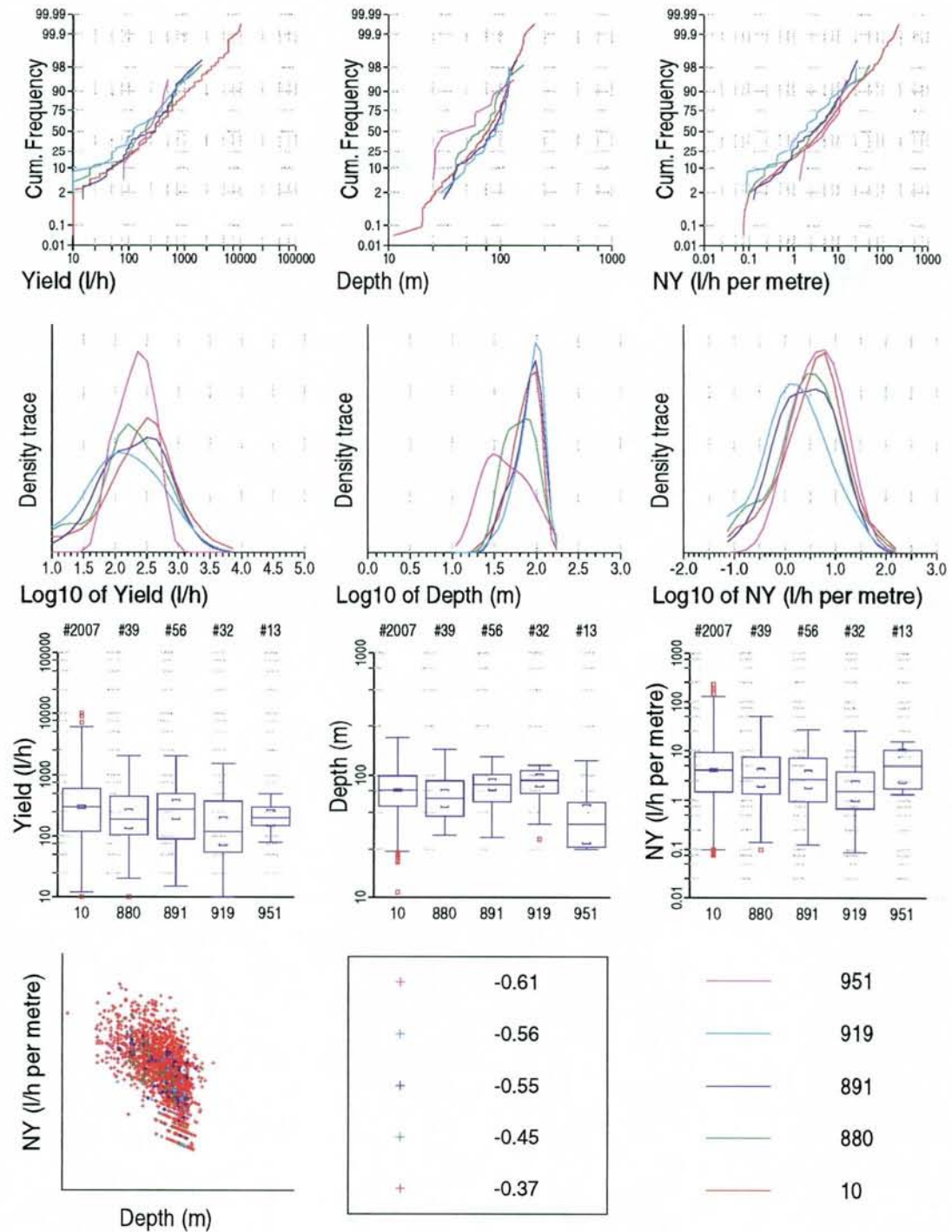
All boreholes within each sub-area



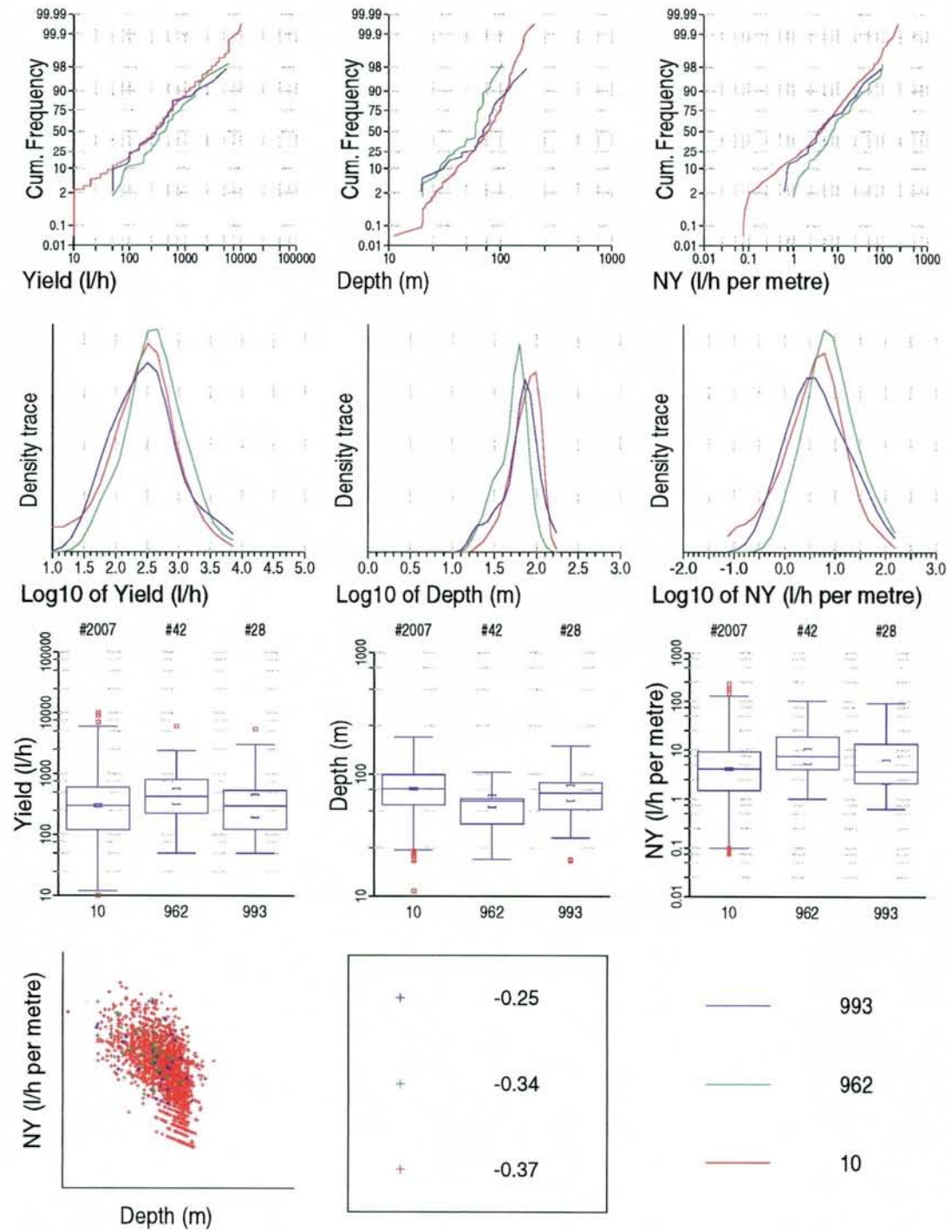
All boreholes within each sub-area



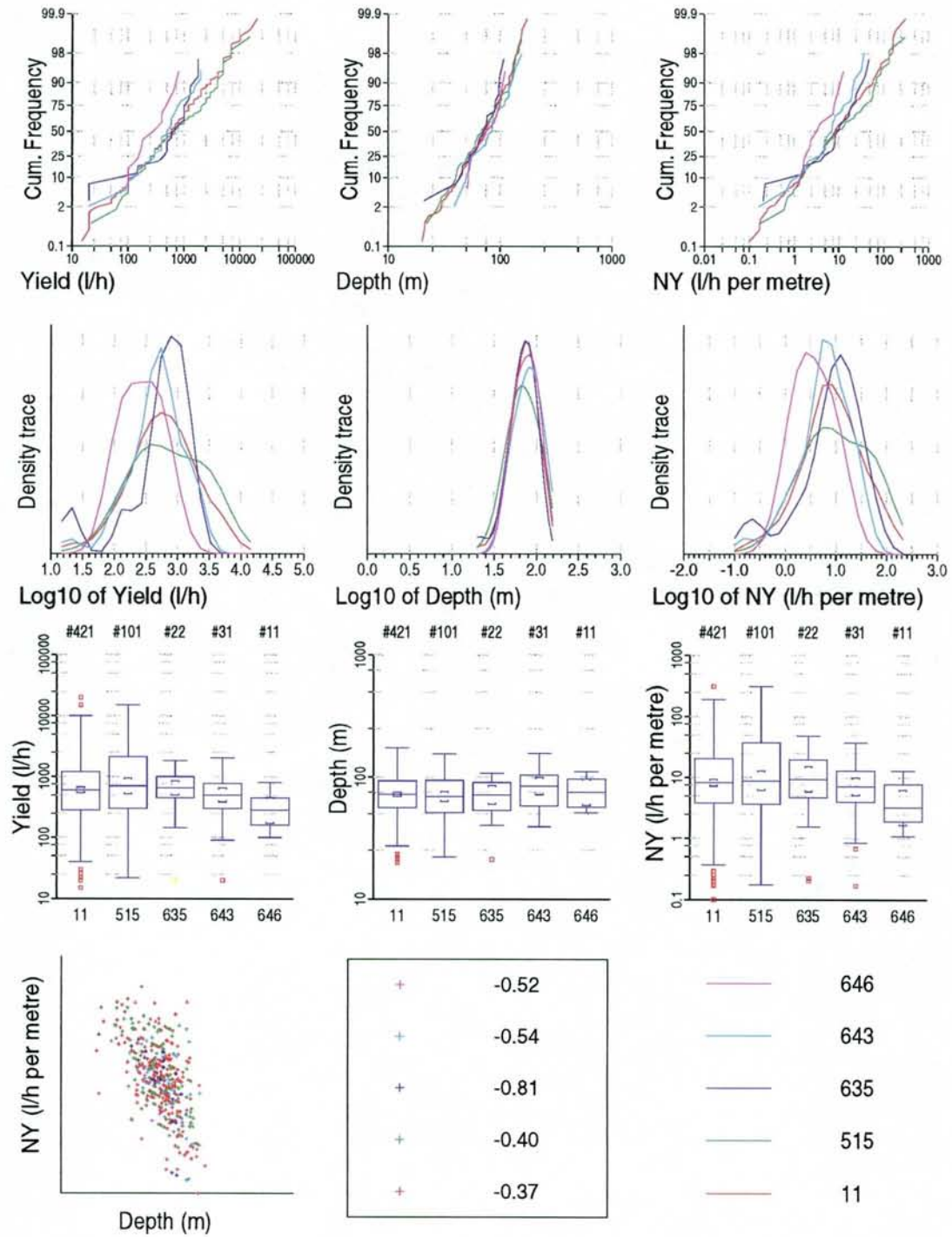
All boreholes within each sub-area



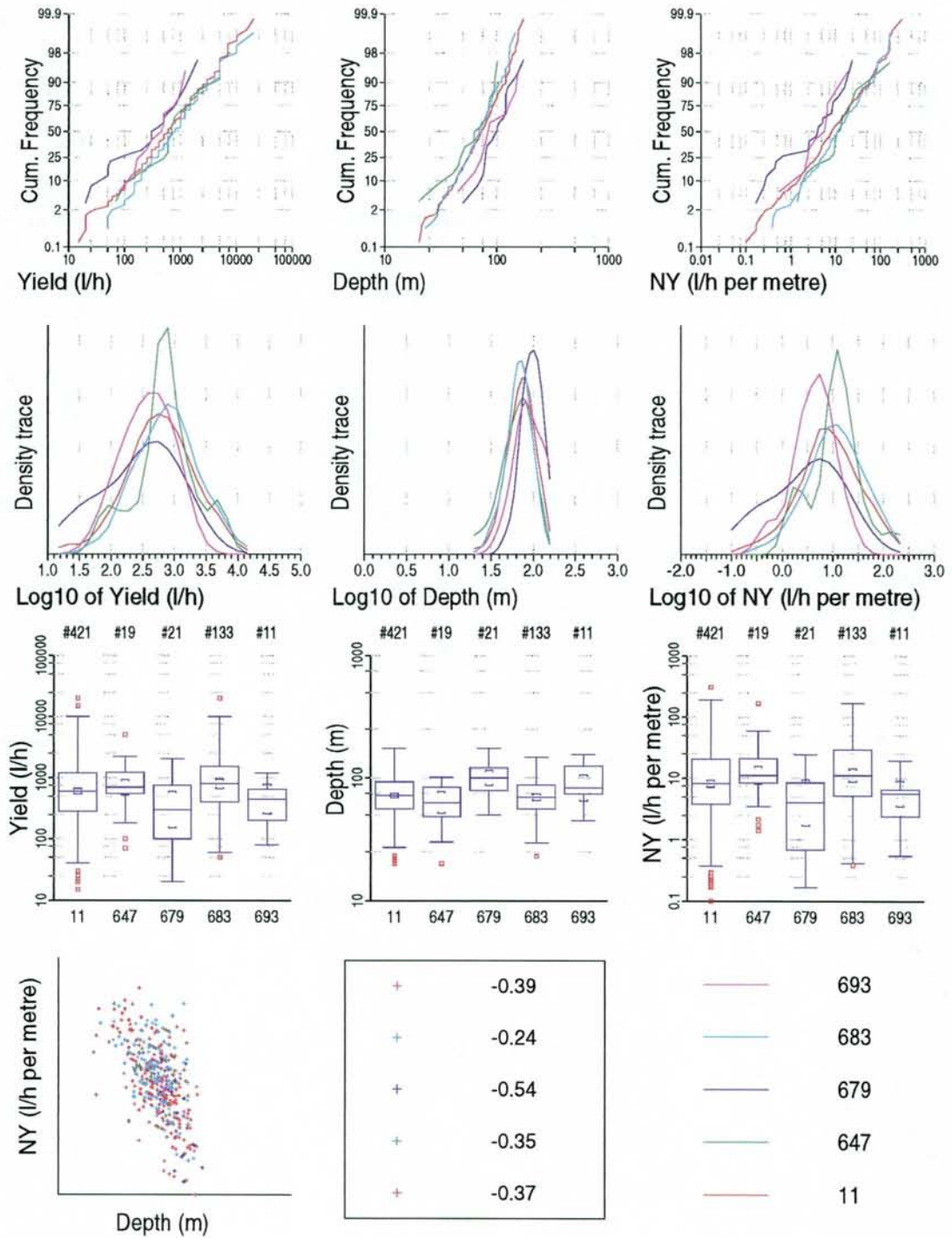
All boreholes within each sub-area



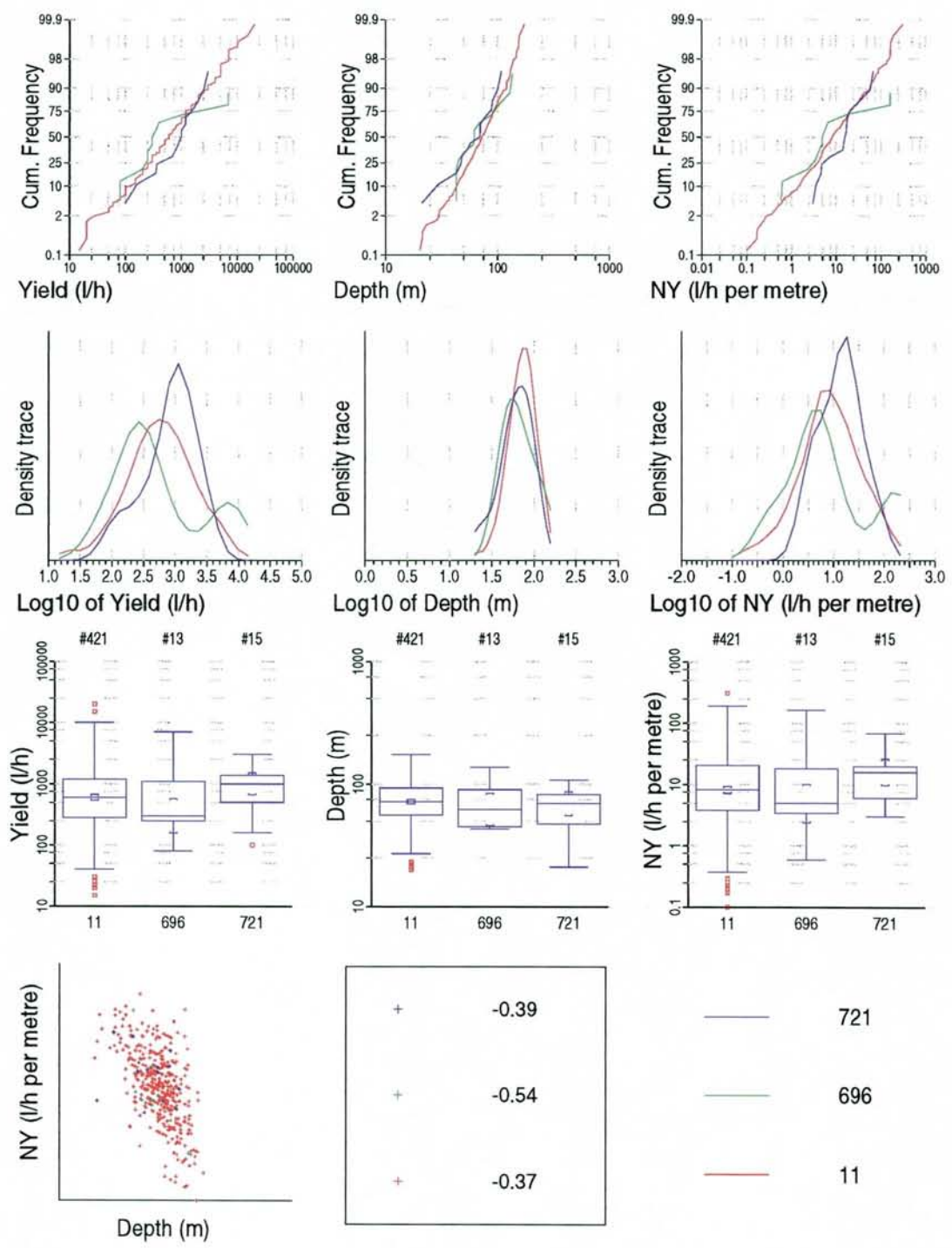
All boreholes within each sub-area



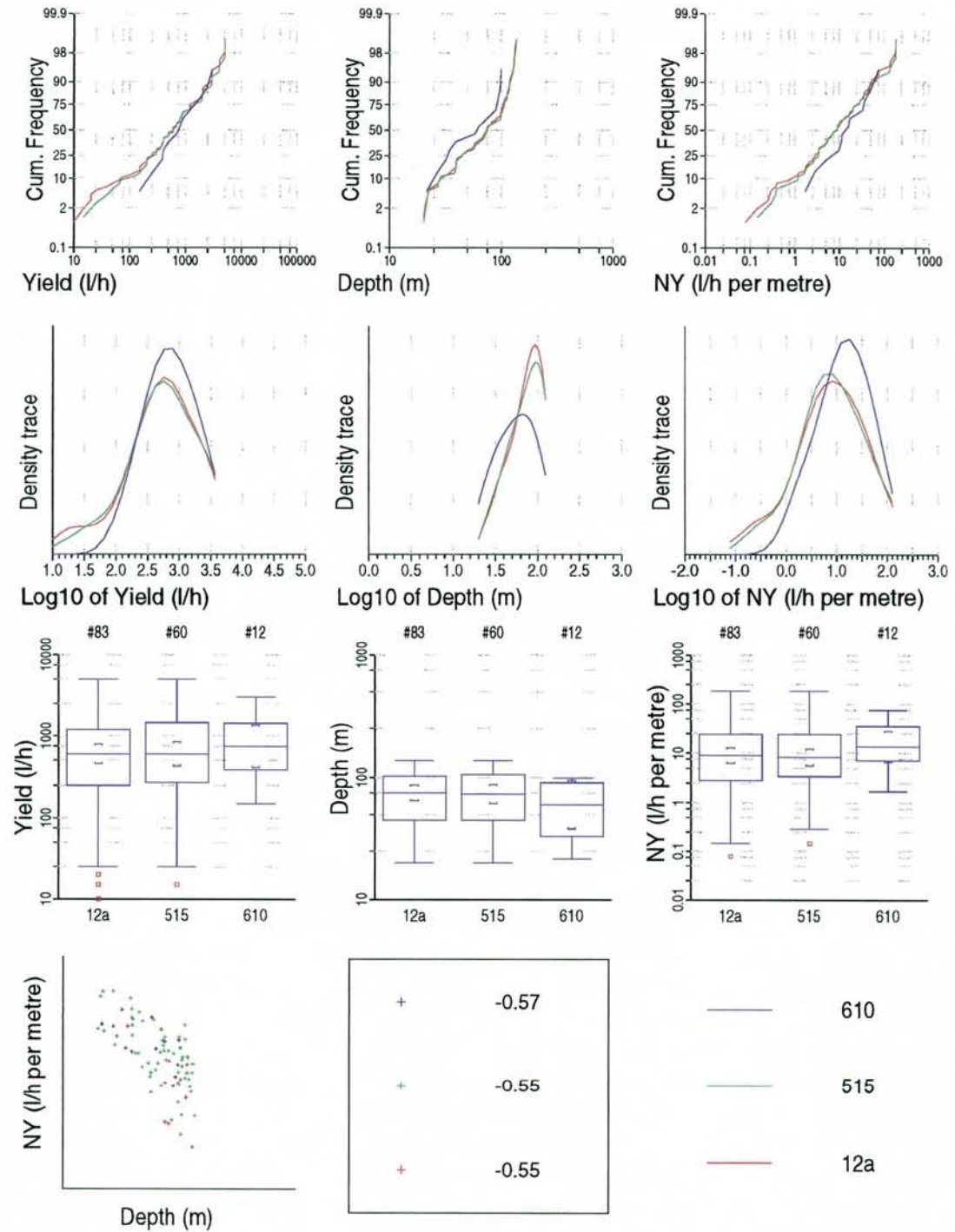
All boreholes within each sub-area



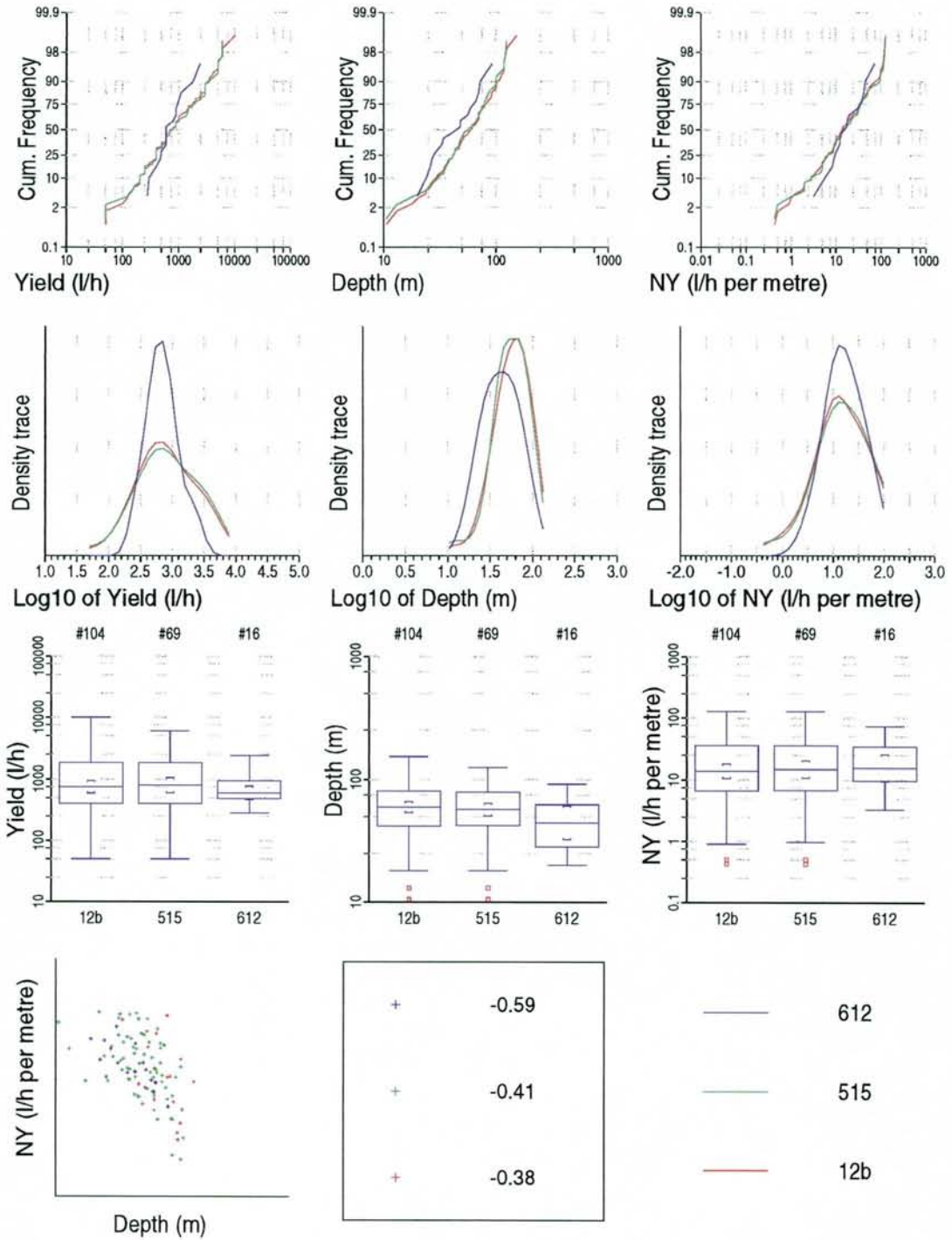
All boreholes within each sub-area



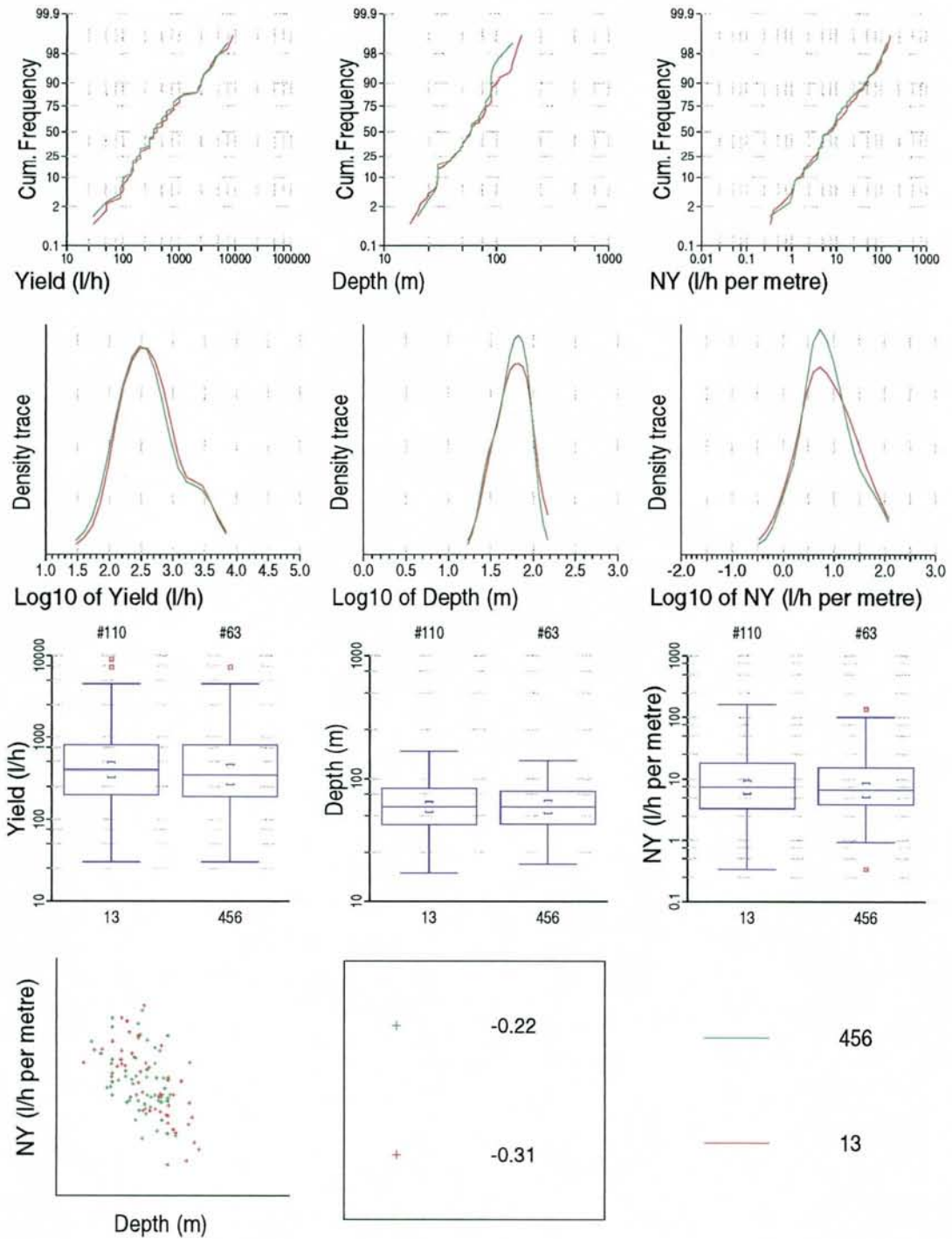
All boreholes within each sub-area



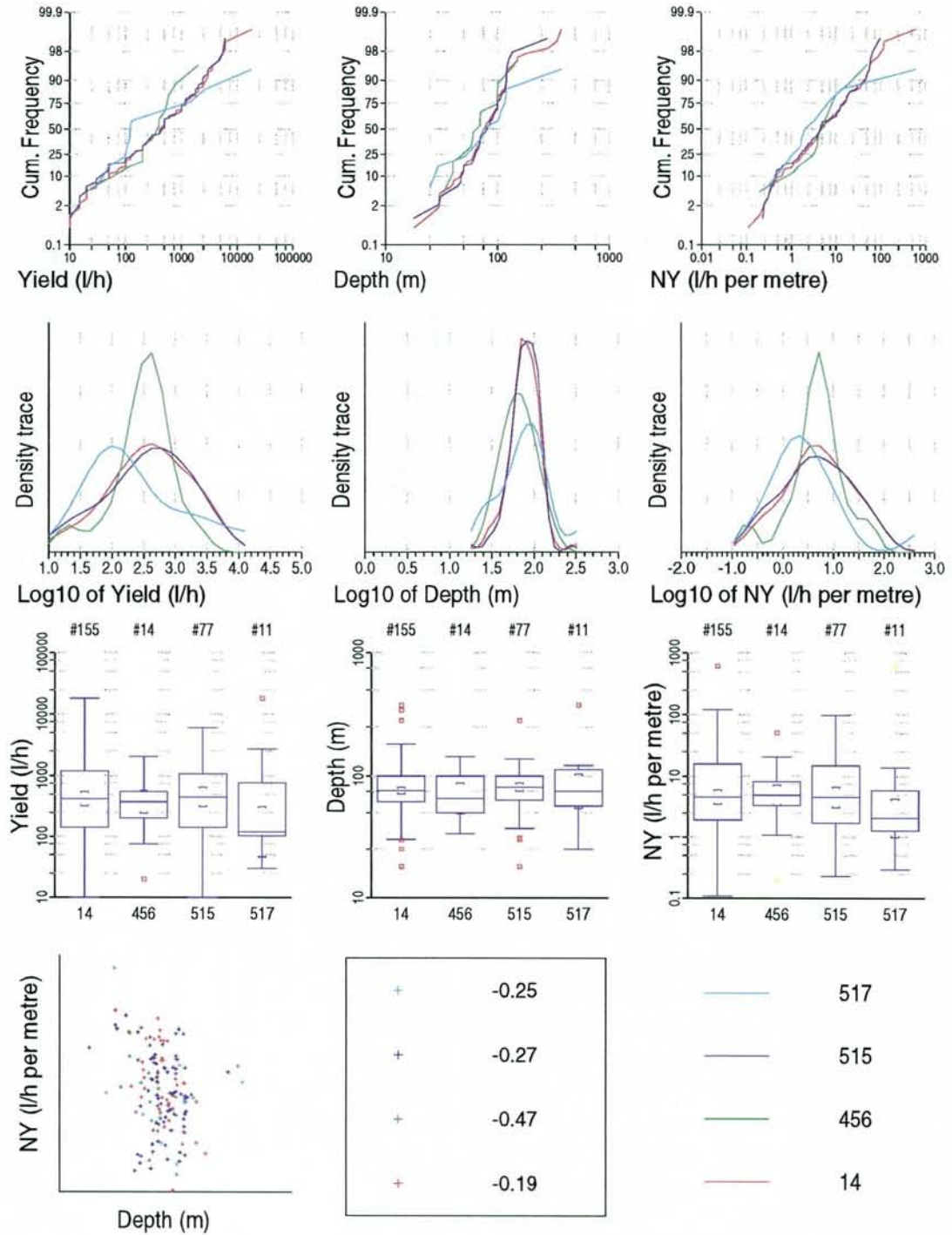
All boreholes within each sub-area



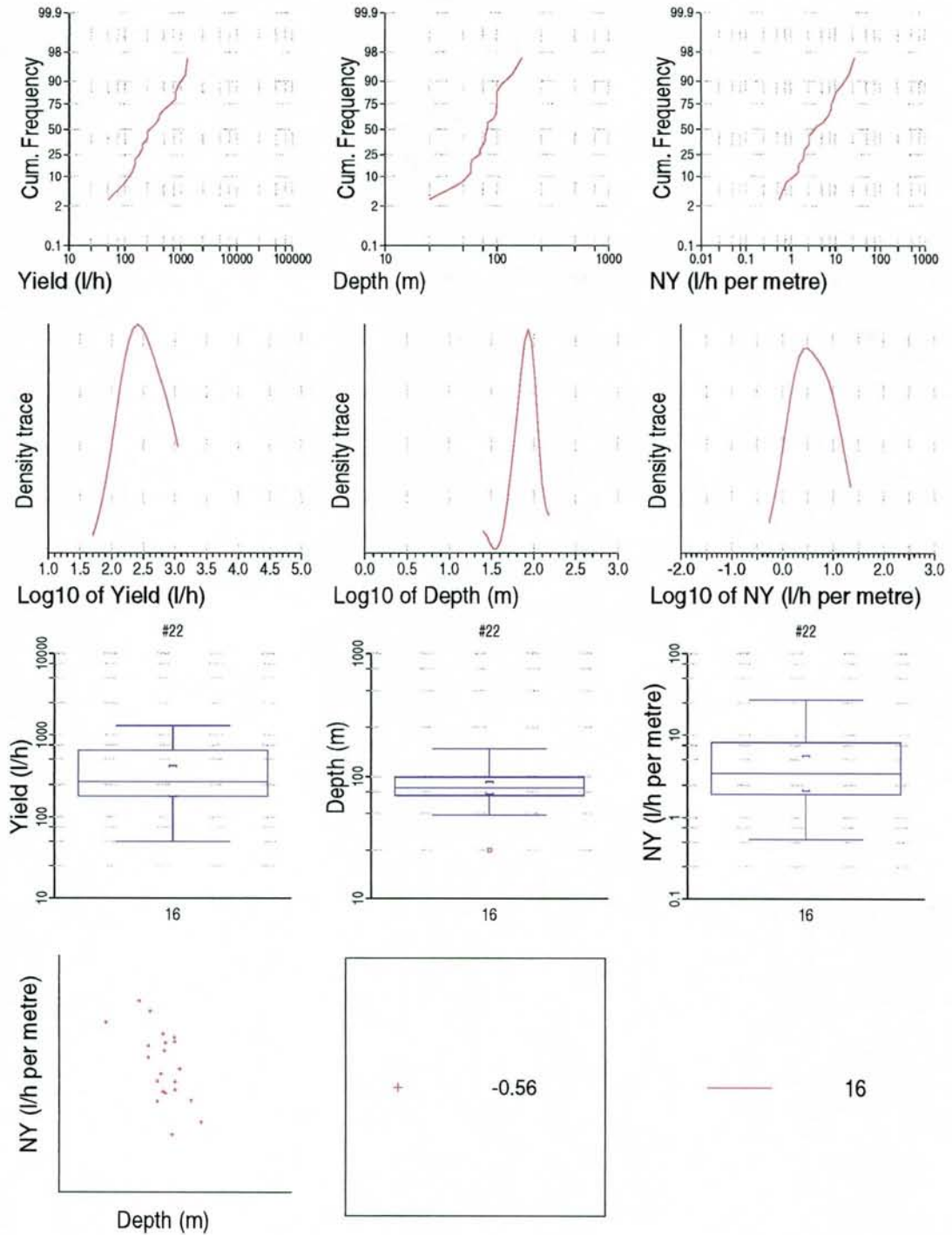
All boreholes within each sub-area



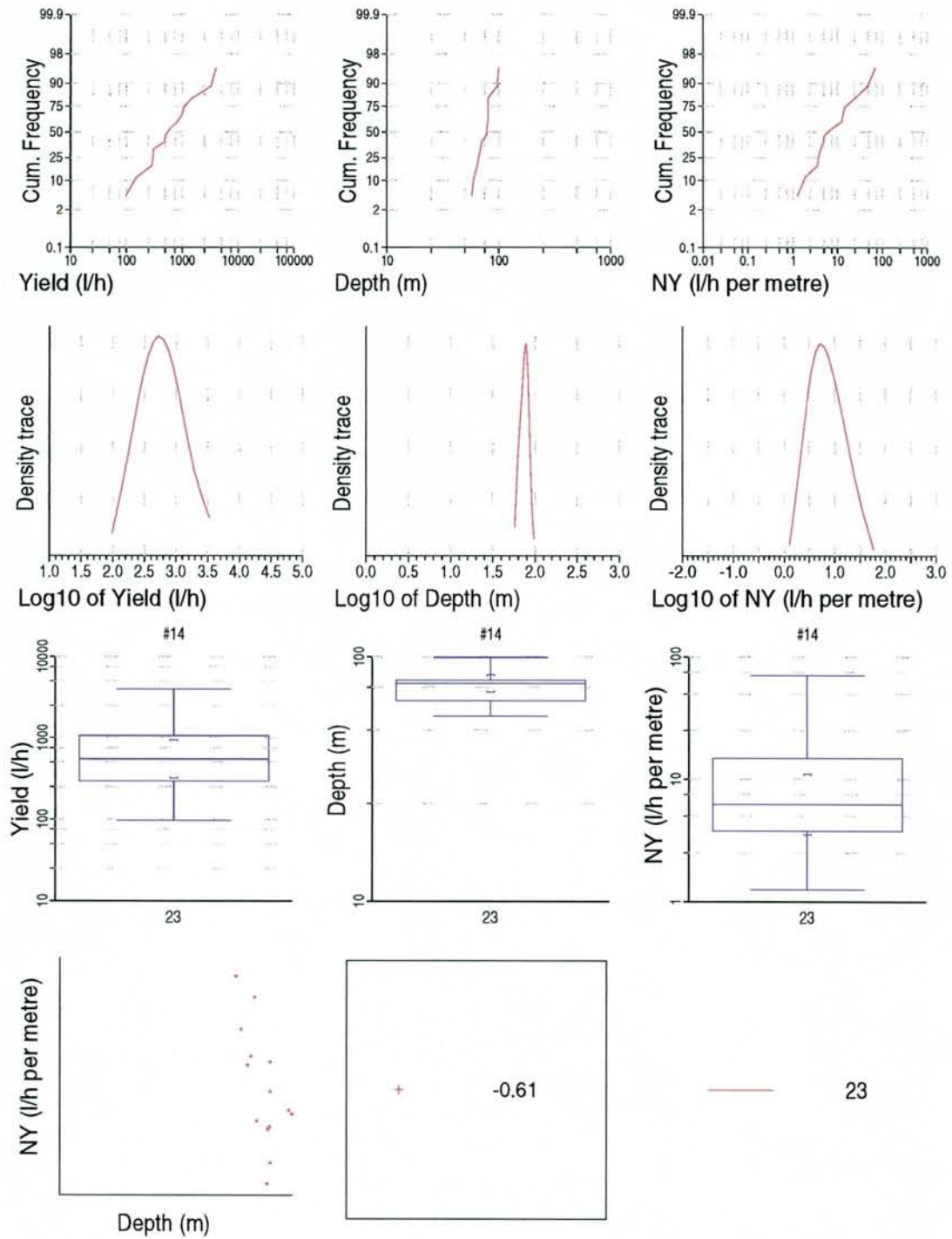
All boreholes within each sub-area



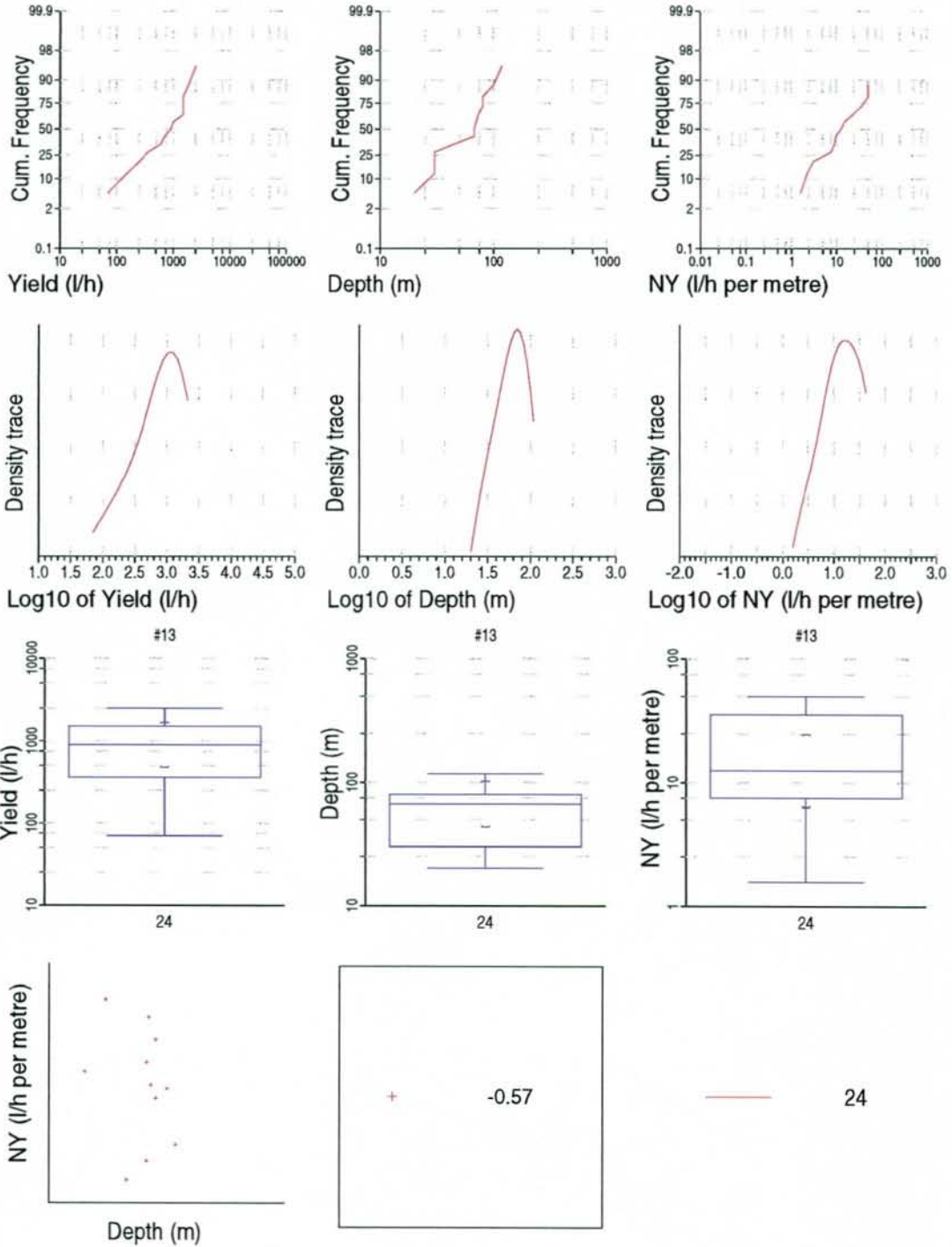
All boreholes within each sub-area



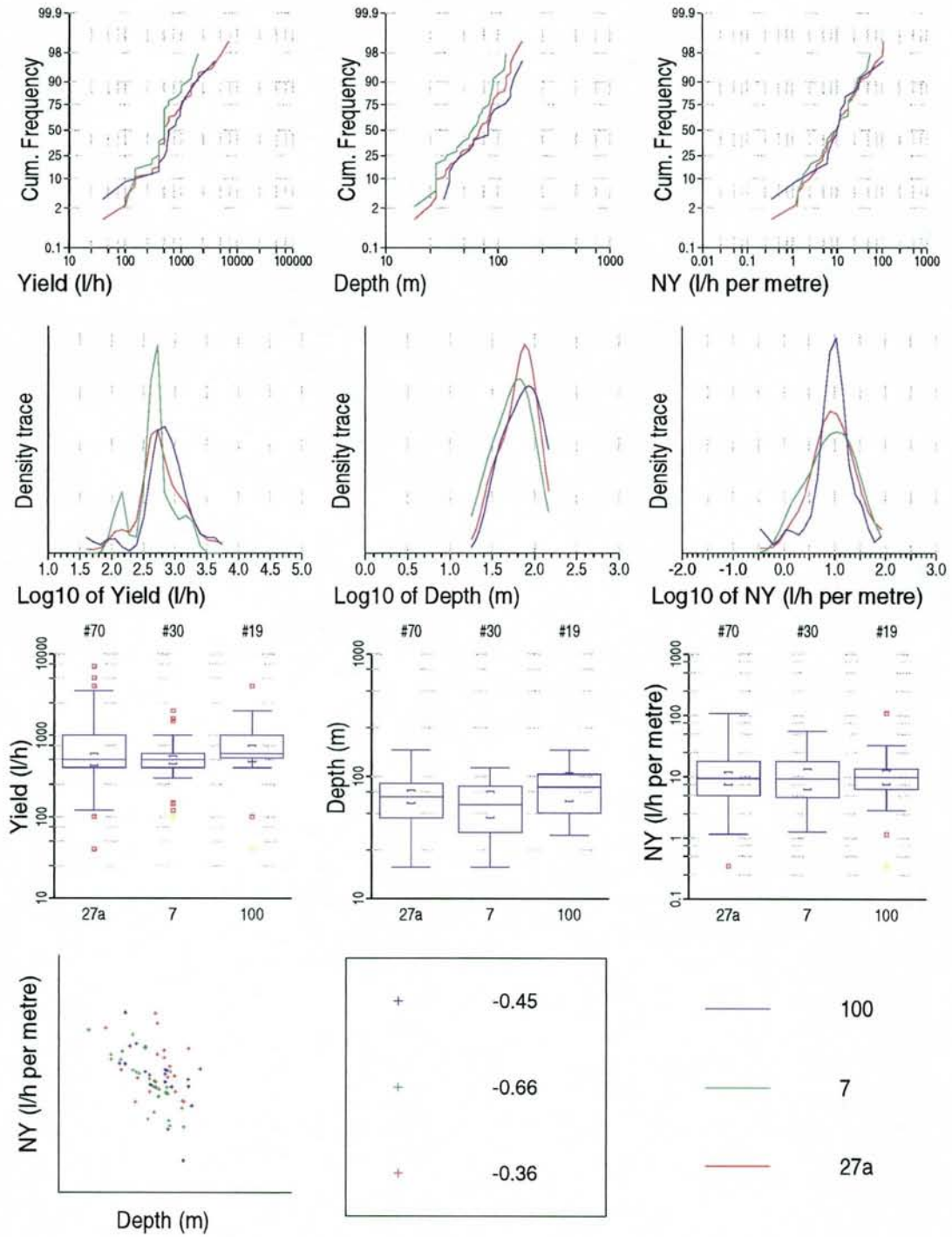
All boreholes within each sub-area



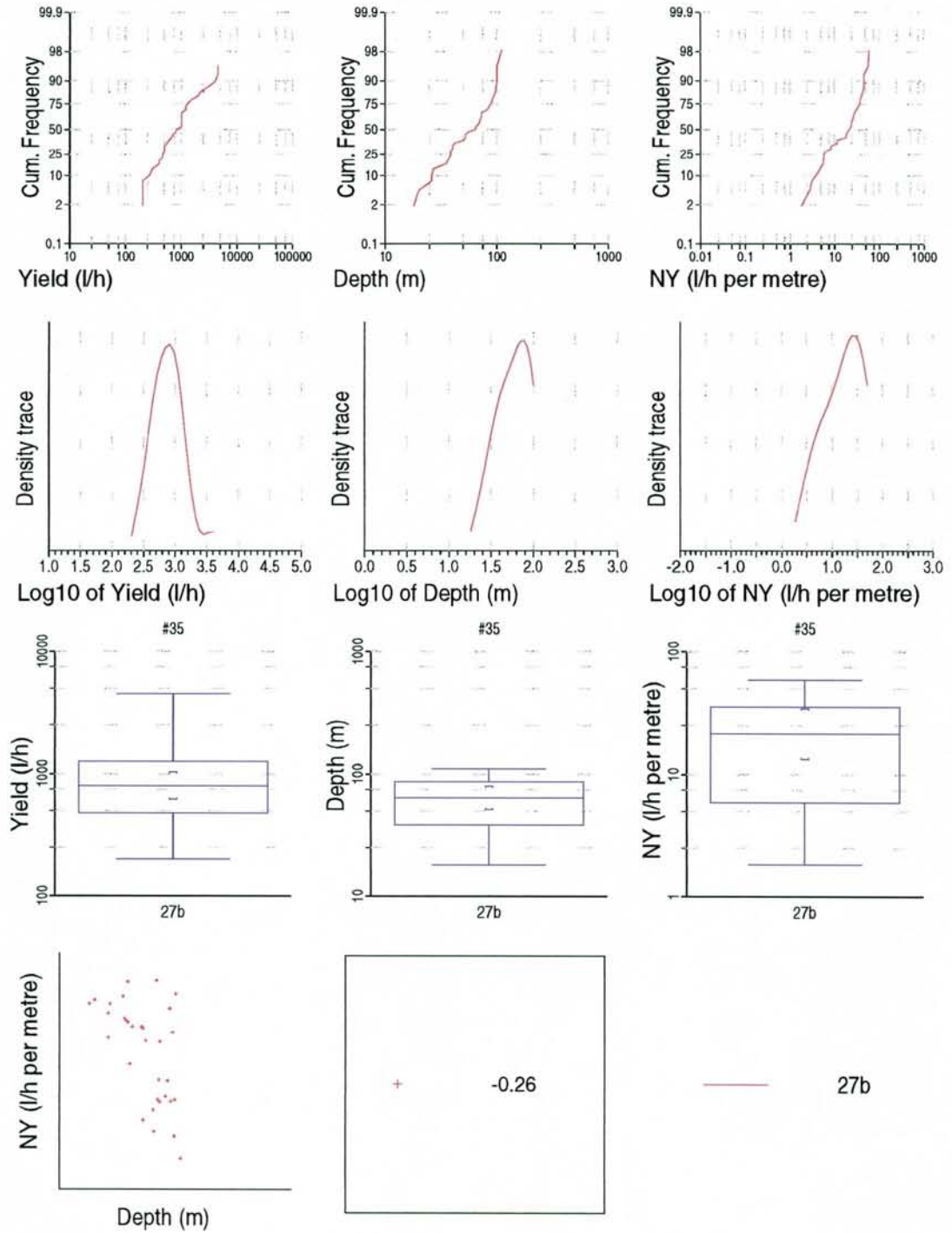
All boreholes within each sub-area



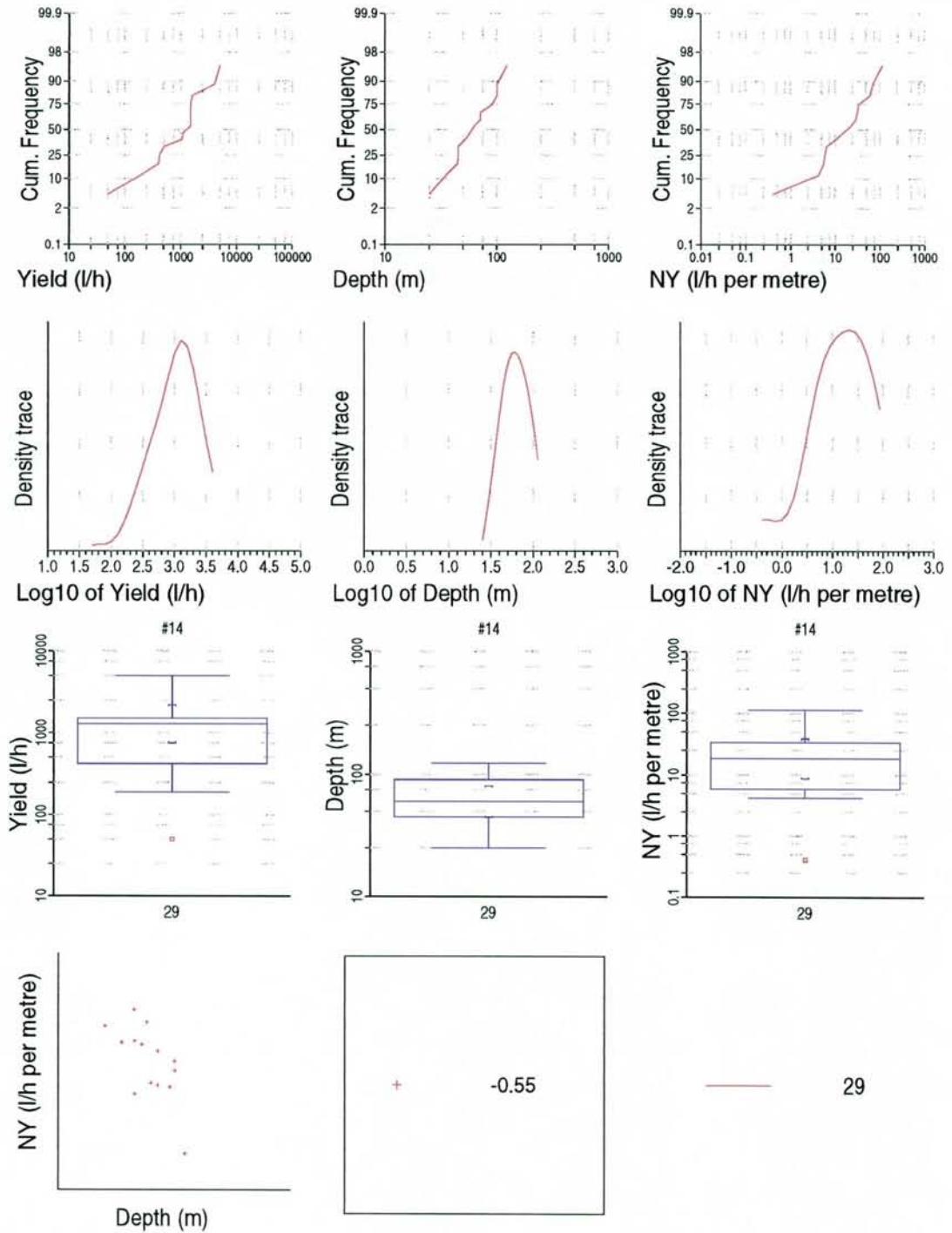
All boreholes within each sub-area



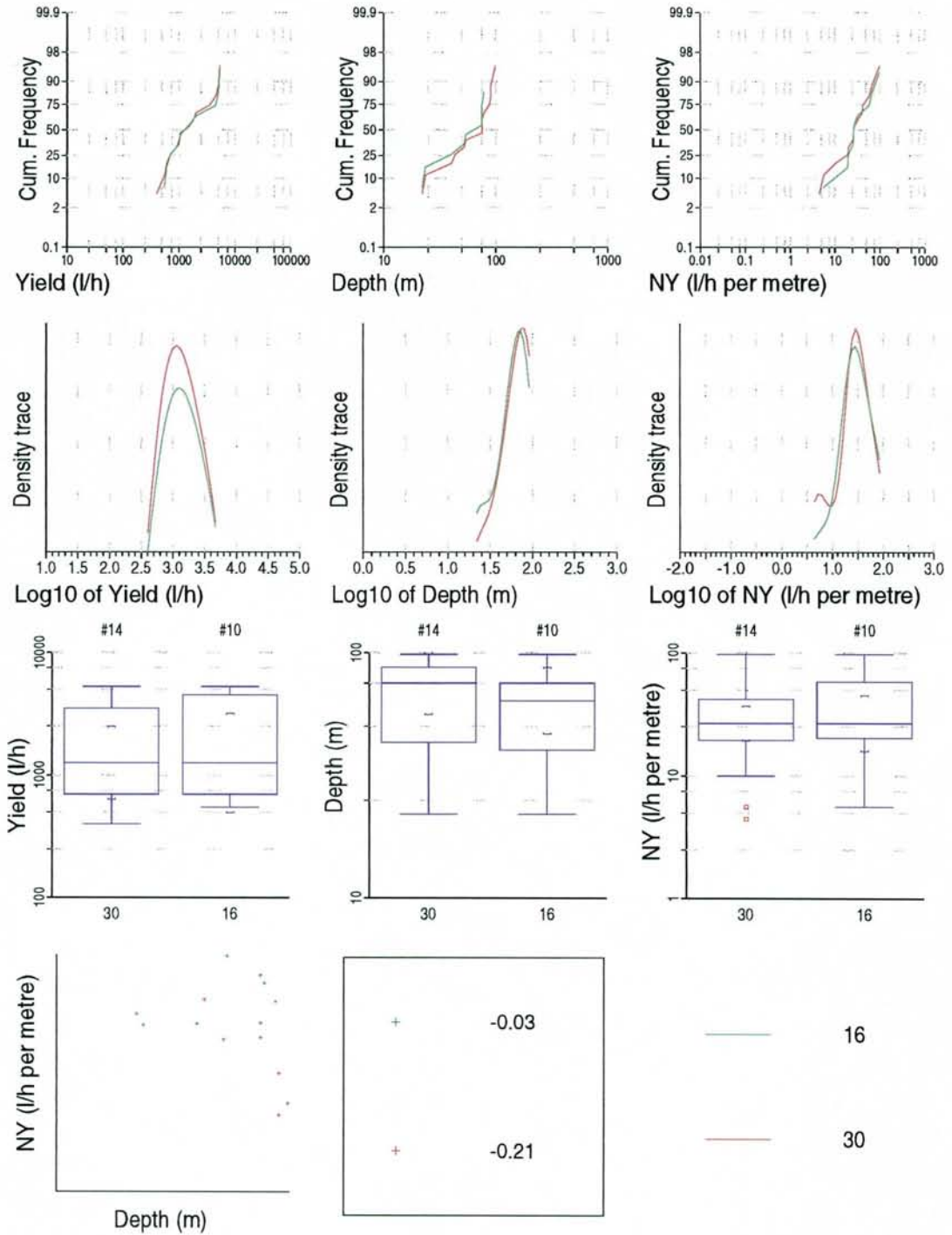
All boreholes within each sub-area



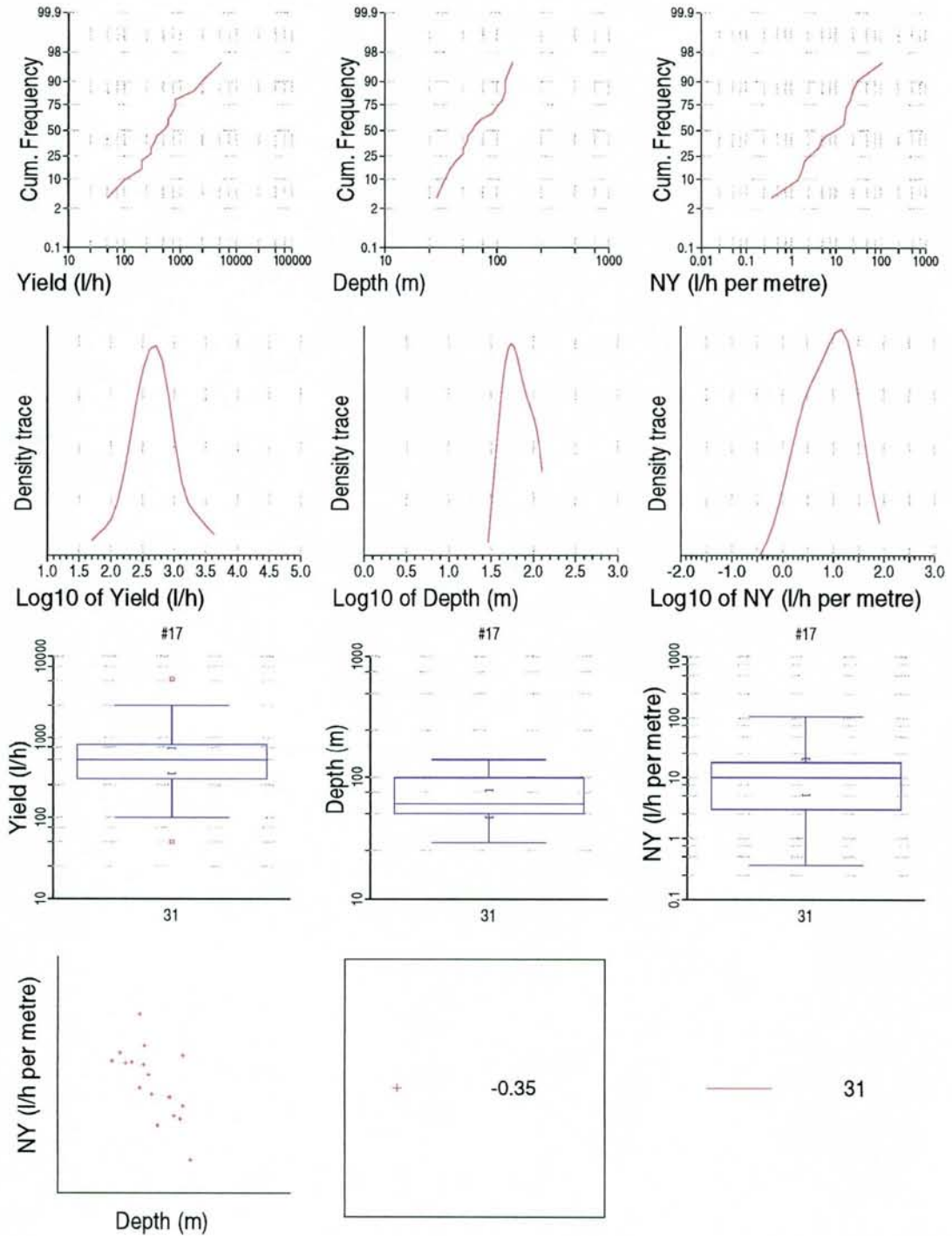
All boreholes within each sub-area



All boreholes within each sub-area



All boreholes within each sub-area



Appendix D

Figure 6.3.5: XY-plots of depth (metre) versus normalised yield (L/h per drilled metre) for all bedrock boreholes within each of the 110 bedrock entities

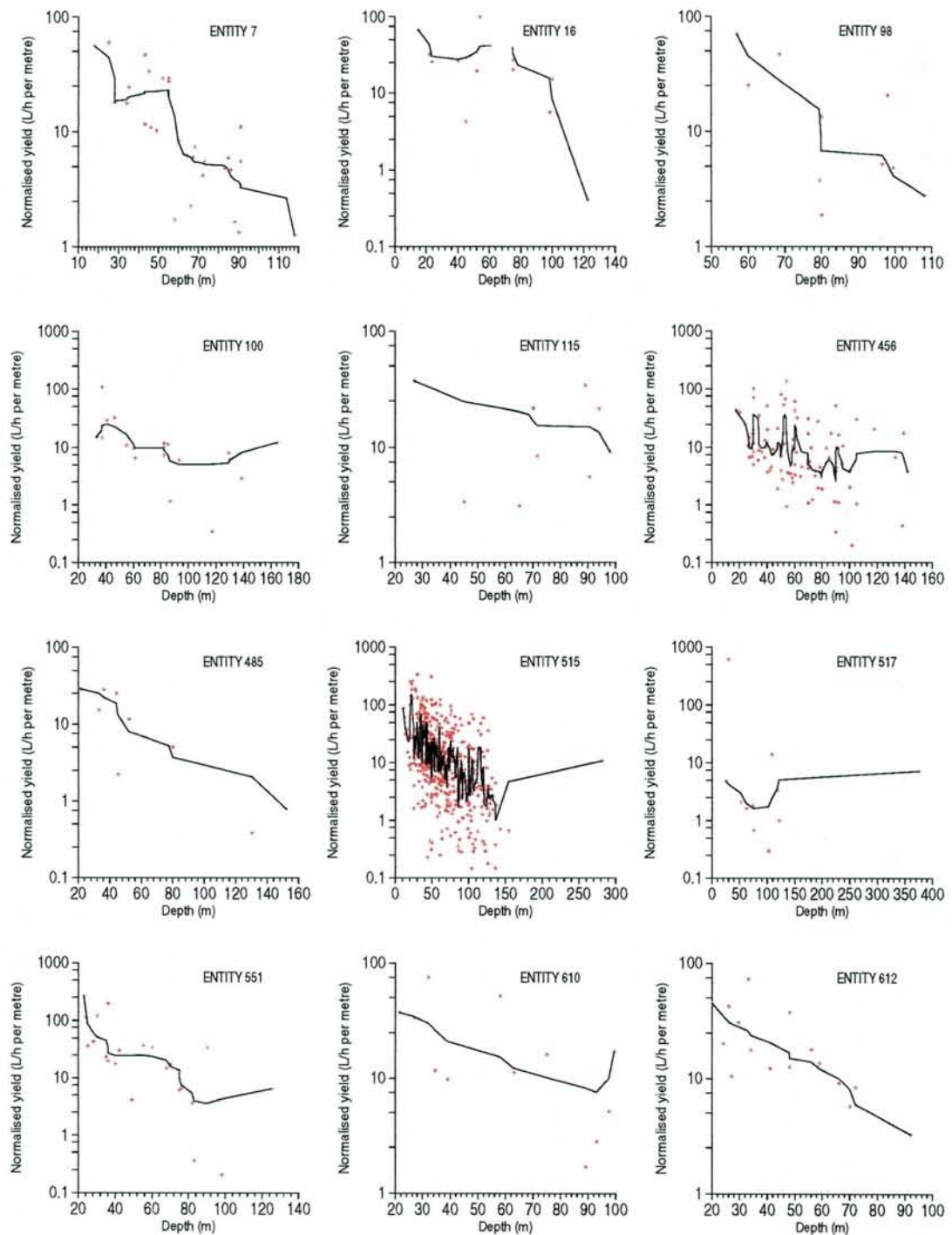


Figure 6.3.5 *XY-plots of depth (metre) versus normalised yield (L/h per drilled metre) for all bedrock boreholes within each of the 110 bedrock entities. The solid line were constructed using the smoothing method of the DAS-program (see text for explanation).*

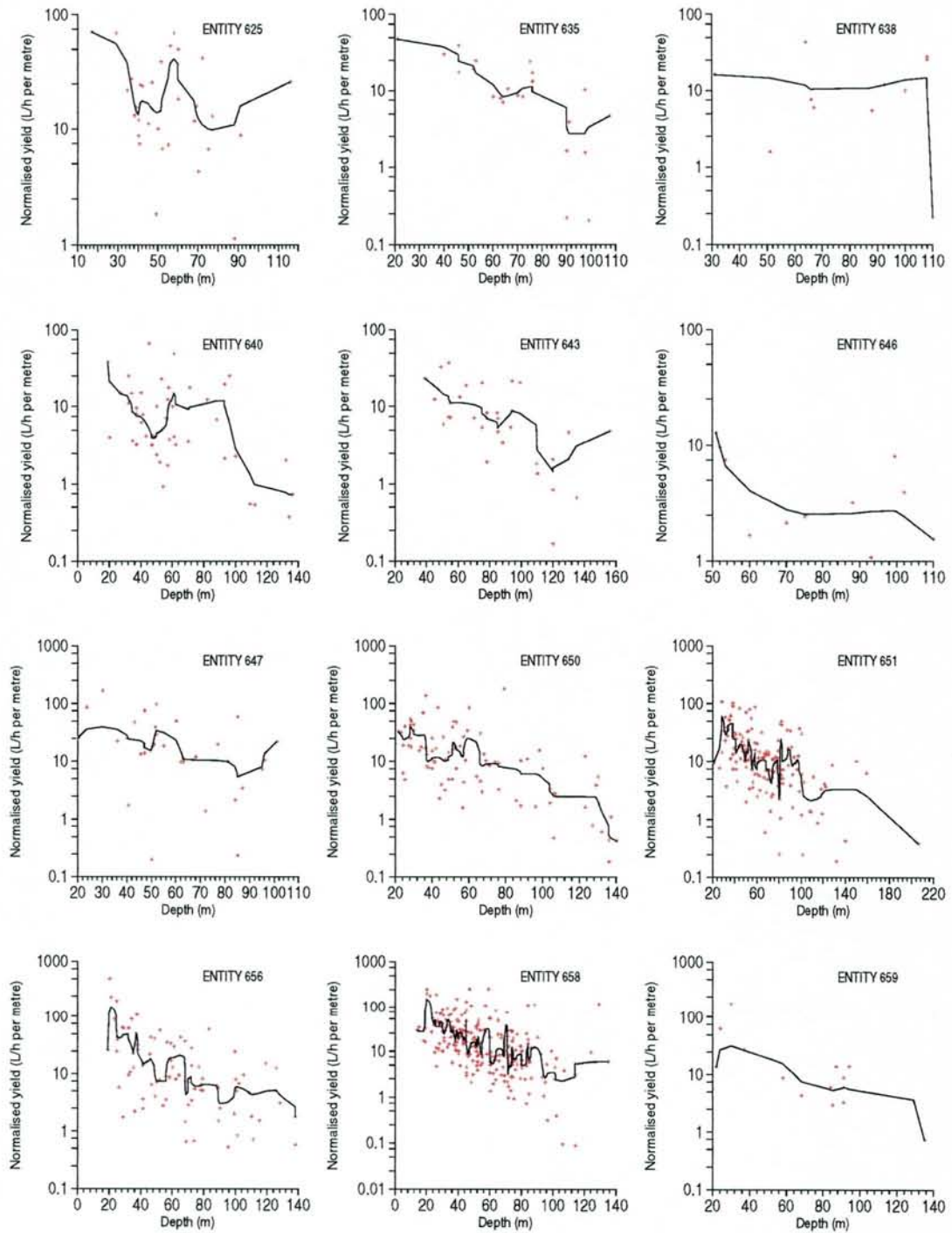


Figure 6.3.5 (continued).

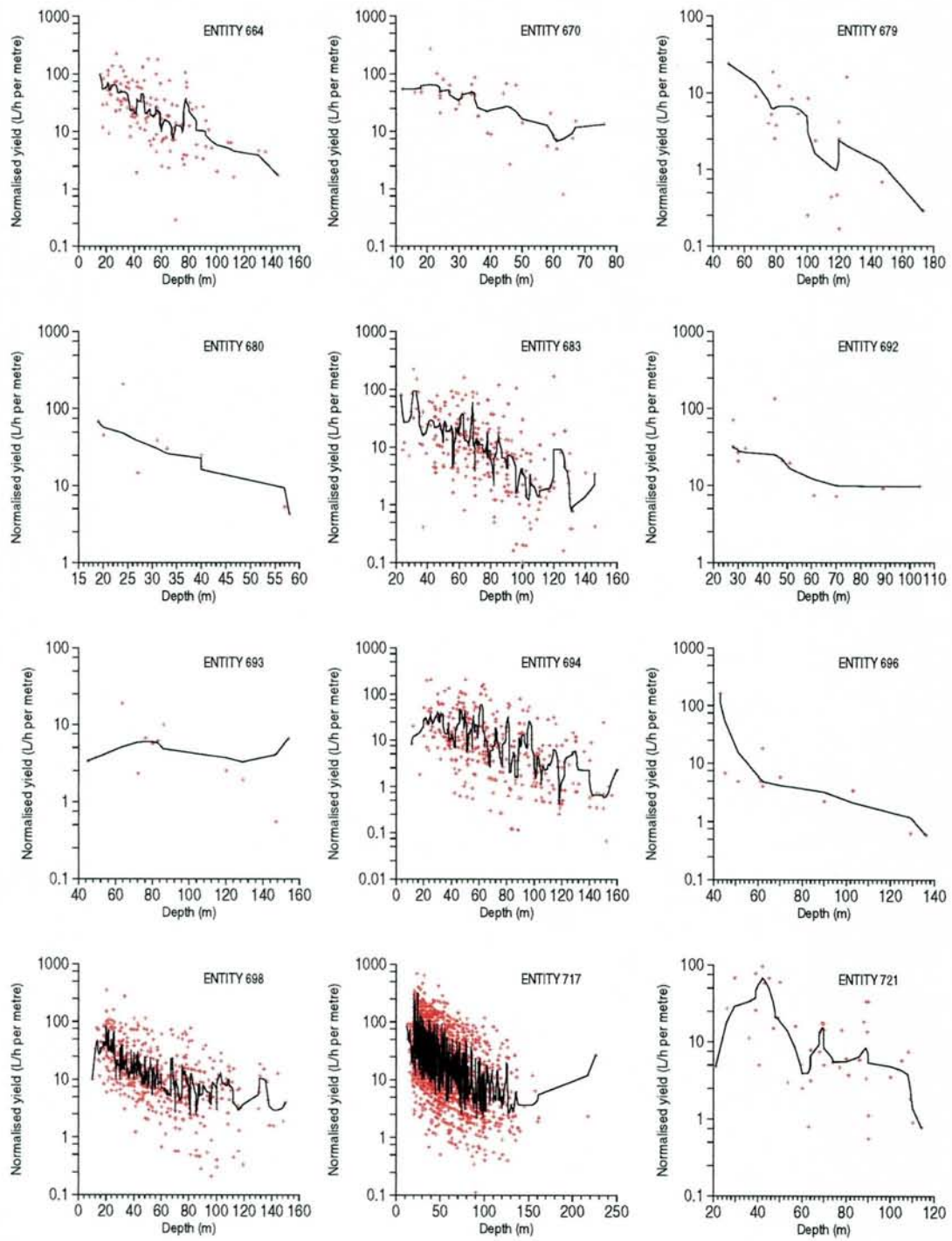


Figure 6.3.5 (continued).

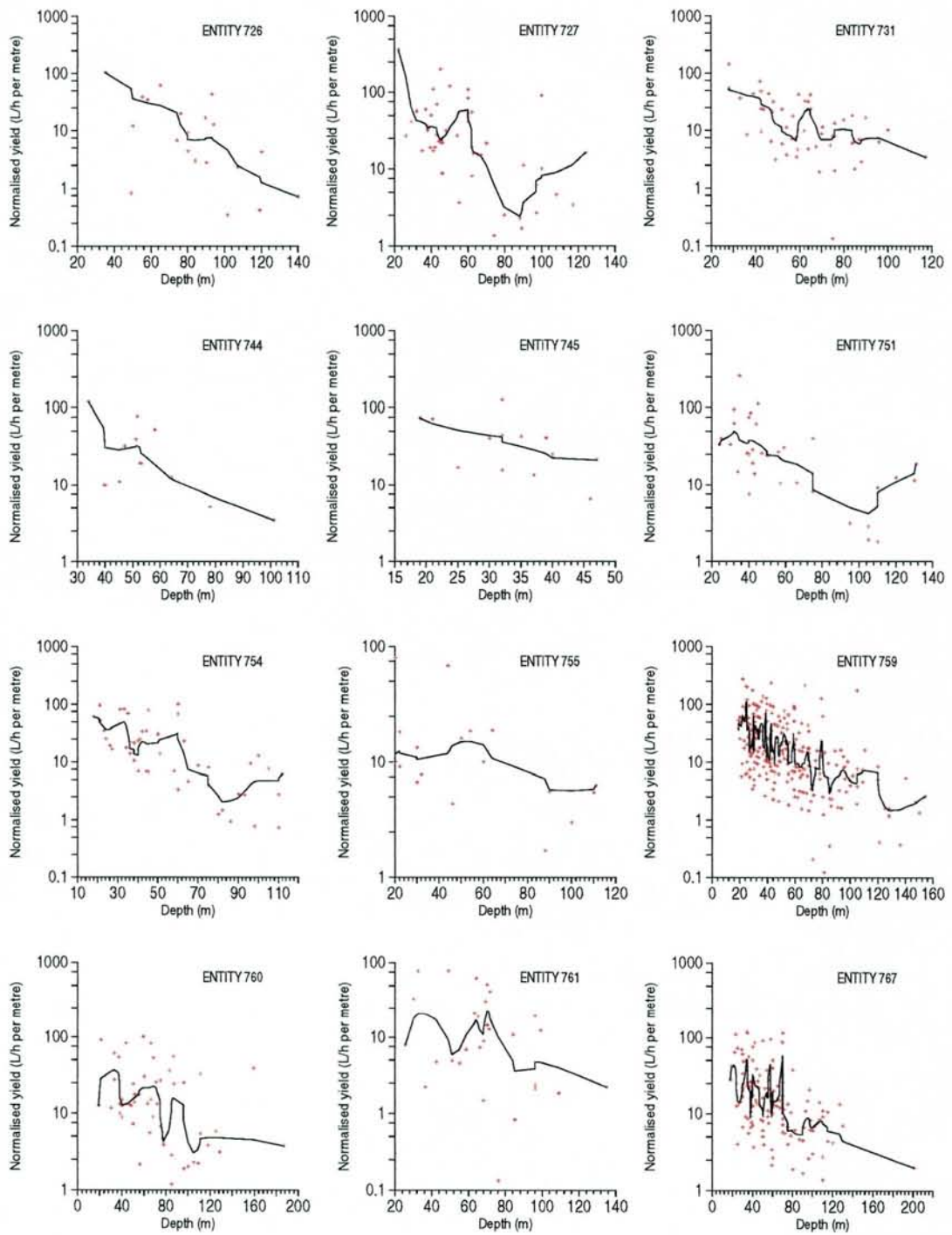


Figure 6.3.5 (continued).

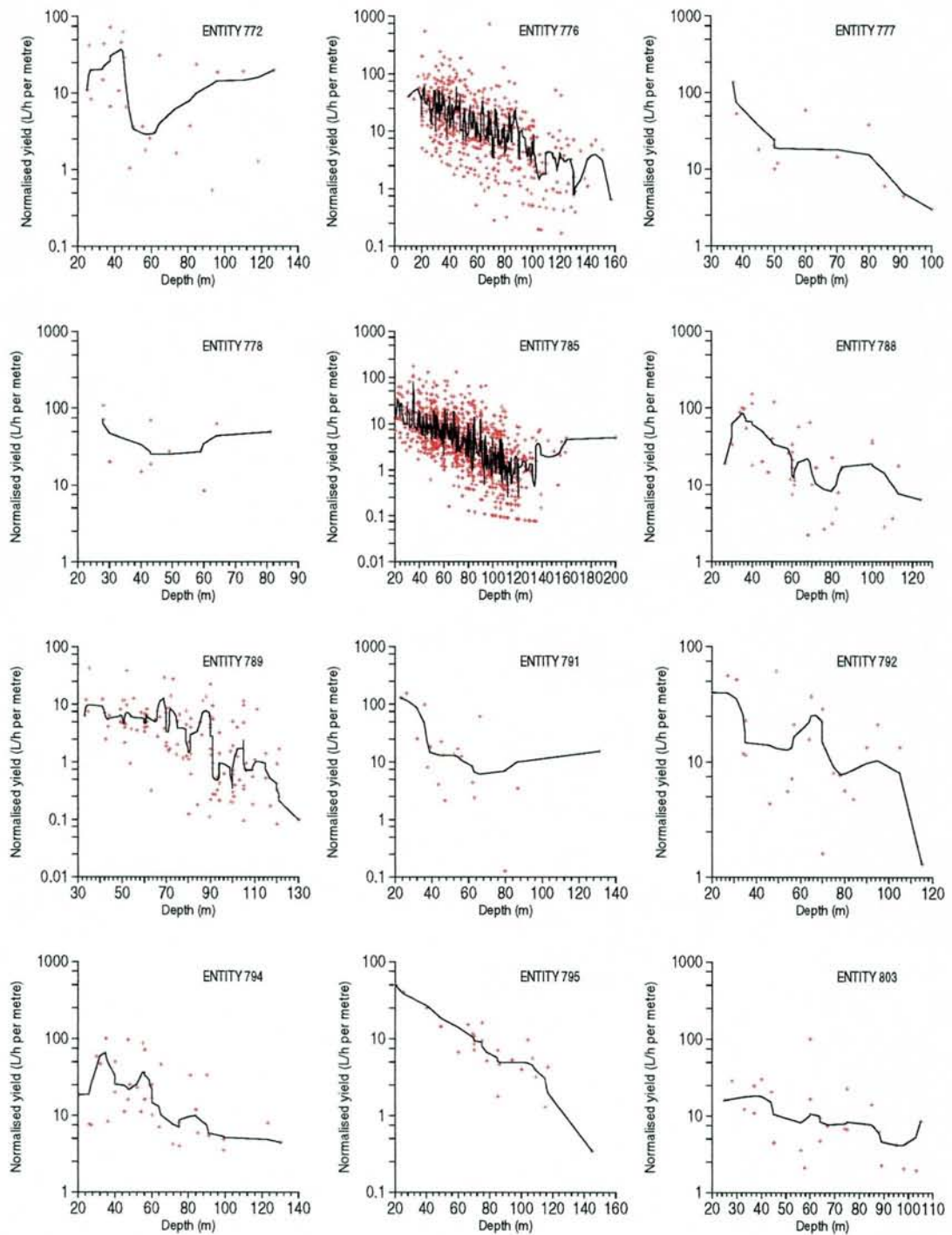


Figure 6.3.5 (continued).

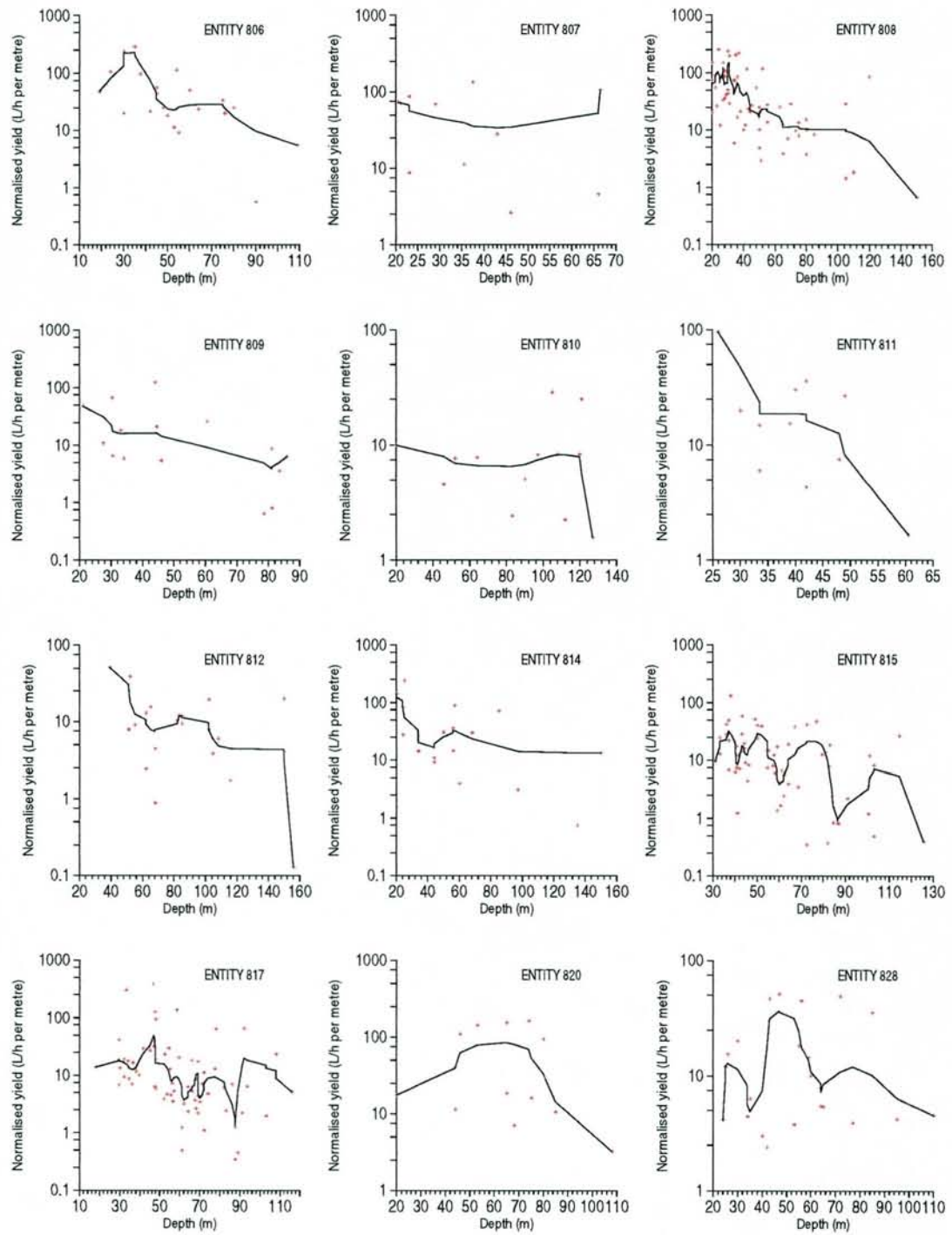


Figure 6.3.5 (continued).

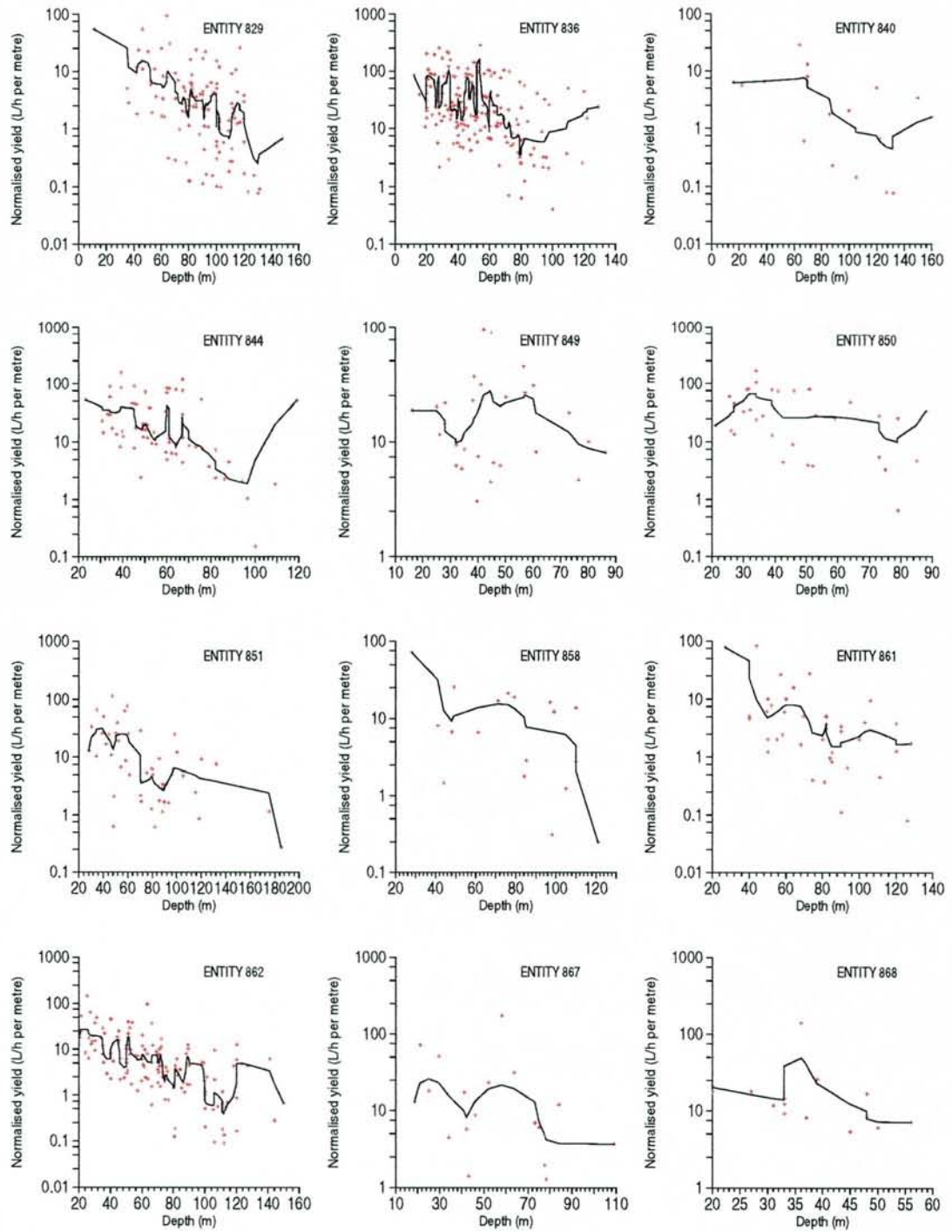


Figure 6.3.5 (continued).

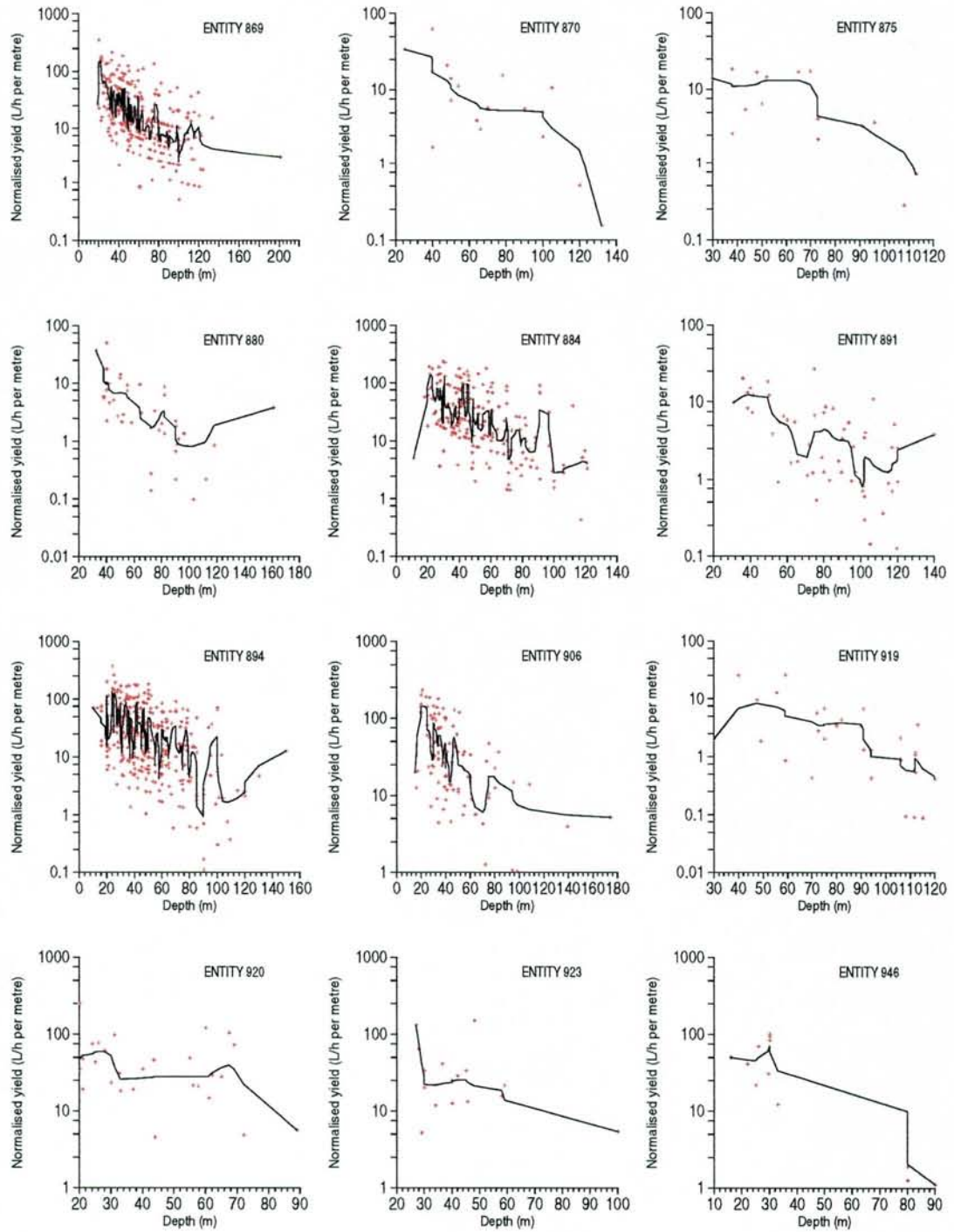


Figure 6.3.5 (continued).

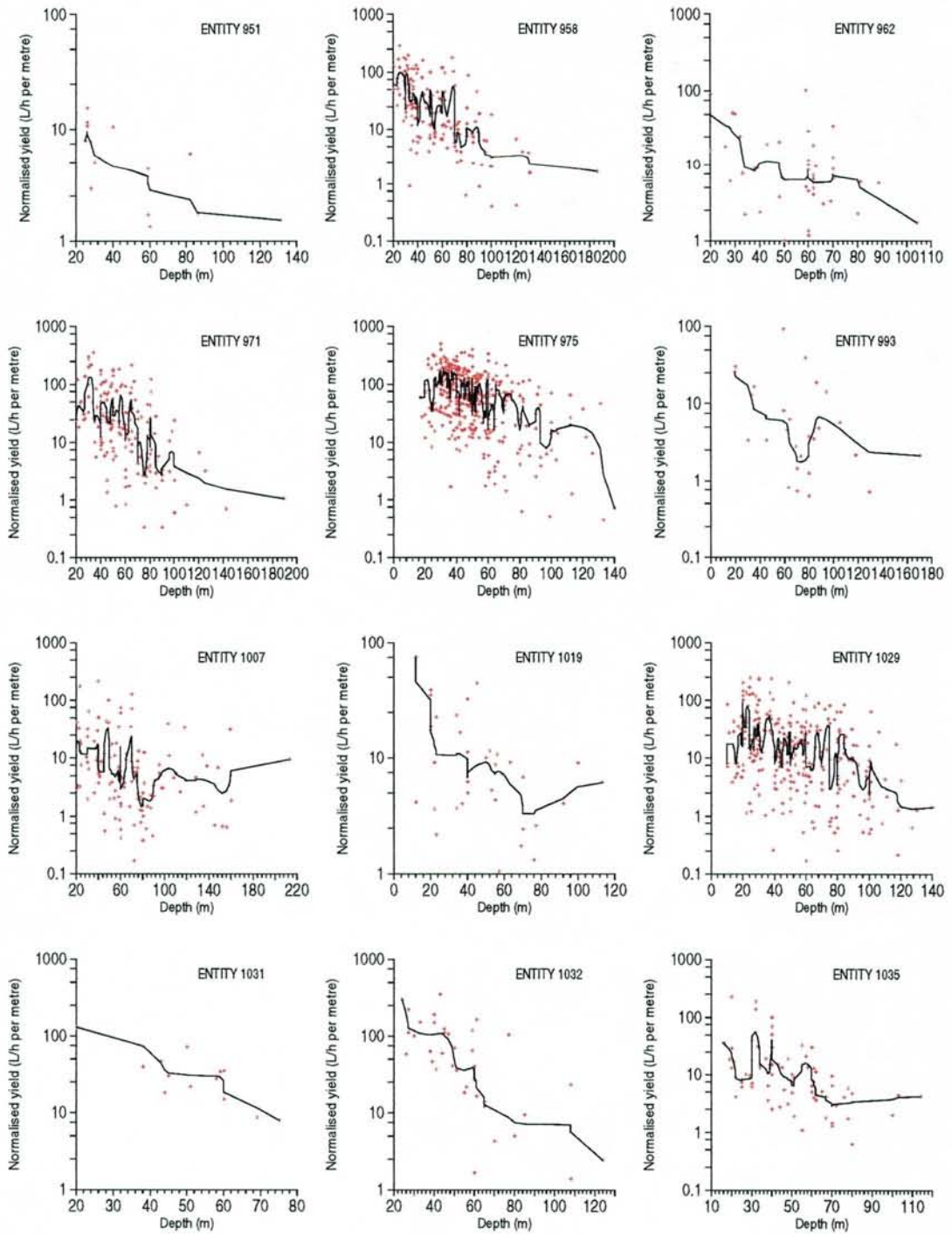


Figure 6.3.5 (continued).

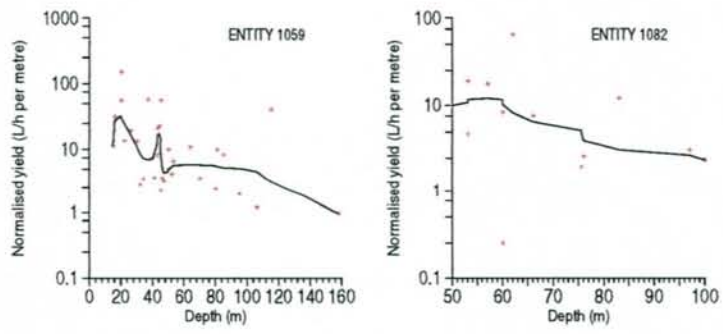


Figure 6.3.5 (continued).

The various bedrock types used in this thesis. The rocktype number refers to the digitised bedrock map of Norway and adjacent ocean areas (Sigmond 1992). See also Table 6.3.1.

- 54 Permian plutonic rocks (Oslo Region)
- 57 Permian volcanic rocks, with subordinate sedimentary rocks (Oslo Region)
- 64 Devonian sedimentary rocks, mainly sandstone and conglomerate
- 67 Upper Silurian sandstone
- 71 Caledonian granite to tonalite
- 72 Caledonian gabbro, diorite, ultramafic rocks
- 74 Cambro-Silurian meta-sediments of the Caledonian mountain chain and the Oslo Region
- 75 Cambro-Silurian limestone and marble
- 76 Cambro-Silurian greenstone, greenschist, amphibolite, meta-andesite
- 79 Upper Precambrian quartz sandstone
- 80 Upper Precambrian sandstone, shale, conglomerate
- 81 Upper Precambrian limestone, shale
- 82 Upper Precambrian metasandstone, mainly meta-arkose and quartz schist
- 85 Precambrian rocks of different origin in Caledonian nappes
- 86 Caledonian charnockitic to anorthositic rocks
- 87 Precambrian granite to tonalite
- 88 Precambrian amphibolite, gneiss
- 90 Precambrian metamorphosed sedimentary and volcanic rocks, gneiss
- 91 Precambrian gneiss, migmatite, foliated granite, amphibolite (north-western gneiss region)
- 92 Precambrian autochthonous granite to tonalite
- 94 Precambrian autochthonous gabbro, amphibolite, ultramafic rocks
- 95 Precambrian metasandstone, mica schist, conglomerate, supracrustal gneisses
- 96 Precambrian metabasalt, meta-andesite, amphibolite
- 97 Precambrian metarhyolite, metarhyodacite
- 98 Precambrian gneiss, migmatite, foliated granite, amphibolite

The various bedrock entities (sorted in ascending order) used in this thesis. The rocktype and the number of boreholes within each bedrock entity are also listed. See also Chapter 2.3.

Entity	Number of boreholes	Rock-type	Entity	Number of boreholes	Rock-type	Entity	Number of boreholes	Rock-type	Entity	Number of boreholes	Rock-type
7	35	82	683	266	91	792	24	80	868	17	94
16	14	80	692	12	98	794	40	74	869	336	74
98	10	74	693	11	76	795	24	74	870	18	76
100	19	85	694	363	74	803	25	80	875	15	74
115	10	96	696	13	76	806	25	74	880	39	76
456	103	74	698	563	80	807	11	97	884	231	75
485	10	76	717	2402	98	808	82	75	891	56	71
515	525	91	721	50	88	809	15	95	894	368	74
517	11	90	726	20	74	810	13	67	906	100	57
551	24	80	727	48	80	811	11	95	919	32	72
610	12	90	731	53	85	812	22	92	920	27	74
612	16	90	744	13	98	814	20	74	923	16	57
625	31	76	745	13	81	815	66	97	946	12	74
635	22	90	751	34	79	817	72	94	951	13	72
638	12	85	754	49	81	820	12	67	958	159	54
640	46	80	755	18	74	828	28	98	962	42	91
643	31	90	759	271	80	829	123	91	971	178	54
646	11	64	760	52	97	836	187	54	975	434	57
647	33	87	761	29	74	840	19	85	993	28	76
650	86	74	767	150	74	844	70	98	1007	127	98
651	158	82	772	27	85	849	28	98	1019	37	85
656	87	74	776	619	98	850	33	98	1029	295	92
658	240	86	777	14	79	851	49	95	1031	13	57
659	14	86	778	11	74	858	18	85	1032	37	54
664	135	85	785	1075	86	861	40	72	1035	77	74
670	42	97	788	43	67	862	140	74	1059	32	85
679	21	91	789	135	91	867	18	96	1082	13	92
680	10	95	791	19	74						