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GAWLER REGION GEOCHEMICAL SURVEY, SOUTH AUSTRALIA

VOLUME 1

Patrice de Caritat, Megan E. Lech, Amy Kernich

CRC LEME OPEN FILE REPORT 211

June 2008

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1 ABSTRACT

A low-density geochemical survey of the Gawler region in South Australia was carried out. Samples of transported regolith were collected at 42 sites in a 53,636 km^2 area, giving an average sample density of ~1 site per 1277 km^2. The sampling sites were strategically located near the lower end of large catchments so as to target transported regolith materials that best represent all source lithologies within each catchment. Floodplain or overbank settings accumulate sediments that generally are fine grained and well mixed, and as such are best able to yield a sample representative of the average composition of the catchment. We call these sediments 'outlet sediments' because in some cases they also include an aeolian component.

At each site, a surface sediment sample ('top outlet sediment' or TOS) was collected from a depth of 0 to 10 cm and a deeper sediment sample ('bottom outlet sediment' or BOS) was collected from a depth of ~60-90 cm. The TOS sample was well mixed over the area of a shallow pit and the BOS sample was collected from 3-5 auger holes (or over the bottom of a soil pit) in order to account for local soil heterogeneity (composite samples). All regolith samples were described in terms of texture, Munsell soil colour (dry and moist) and field pH, and each sampling site was described and photographed. At 25 additional sites, some close to regolith sampling sites, groundwater was also collected to compare to the sediment geochemistry; one rainwater sample from a plastic rainwater tank was also collected.

In the laboratory, a split of each bulk sediment sample was subjected to laser particle size analysis (LPSA) and to pH 1:5 (soil:water solution) and electrical conductivity (EC) 1:5 measurements. The remainder of the sample was dried and split into two parts, one for archiving, and the other for analysis. The split for analysis was sieved and the <180 um and <75 um fractions was submitted for analysis for over 60 elements by X-ray fluorescence (XRF), inductively coupled plasma-mass spectrometry (ICP-MS) and ion selective electrode (ISE) analyses at Geoscience Australia (XRF), Acme Laboratories in Vancouver (ICP-MS) and ALS Chemex in Brisbane (ISE) laboratories. At six sites a number of additional size fractions were separated and analysed to determine which size fractions yield the most useful geochemical information. Heavy mineral fractions of a few samples were separated by panning and separation using tetrabromoethane (density 2.955) and analysed by AutoGeoSEM at CSIRO Exploration & Mining (Perth). All resulting data are given in Appendices, as are quality control results.

The groundwater samples were analysed for major and minor element concentrations by inductively coupled plasma-emission spectrometry (ICP-ES) and ion chromatography (IC) at the Australian National University, and by ICP-MS at the University of Canberra. The concentration of Au (and a few other elements) in solution was determined by adsorbing Au on an activated carbon sachet, then ashing and digesting the carbon and analysing by ICP-MS at Ultra Trace Laboratory, Perth. The isotopic composition of O and H of water (Monash University), C and O of dissolved bicarbonate and S and O of dissolved sulfate (University of Calgary) were determined by mass spectrometric methods.

Preliminary investigation suggests that patterns relating to bedrock type (e.g., ultramafic) and mineralisation (e.g., gold) are revealed by the regolith geochemical maps. The groundwater survey was too sparse to support independent interpretation, but when combined with the regolith maps, the groundwater maps indicate corroboration of some of the findings (e.g., As distribution as a pathfinder for Au mineralisation). The Gawler geochemical survey demonstrates that outlet sediments are a useful and widespread sampling medium in Australia and that applying a low-density approach is informative and cost-effective for geochemical surveys over large areas.

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2 INTRODUCTION

2.1 Regolith chemistry

Low-density geochemical baseline surveys have been conducted in many countries for applications in resource evaluation, land use management or health and well-being of humans and animals. These studies add to the development of a global geochemical database which pursues the systematic and standardised sampling and collection of geochemical samples across the globe (Darnley *et al.*, 1995).

The Gawler baseline geochemical survey (Caritat *et al.*, 2006a,b), is one of few of this kind in Australia (e.g., Subramanya *et al.*, 1995). It is part of a series of regional geochemical pilot studies conducted in a joint project between the Cooperative Research Centre for Landscape Environments and Mineral Exploration (CRC LEME) and Geoscience Australia. Other pilot projects have been carried out in the Riverina region of New South Wales (NSW) and Victoria (Caritat *et al.*, 2007) and in the Thomson region of northwestern NSW (Greenfield *et al.*, 2006; Caritat and Lech, 2007). These pilot projects have resulted in the establishment of a National Geochemical Survey of Australia funded by the Australian Government's Onshore Energy Security Program (Caritat *et al.*, 2008). The surveys provide important information on the natural concentration of chemical elements and compounds in the near-surface regolith.

The natural concentrations in geological materials near the Earth's surface vary greatly due to local influences such as geology, biological processes and other factors (Reimann and Caritat, 1998, 2005). Knowing the natural concentrations and regional geochemical patterns can contribute to the nation's triple bottom line (i.e. economy, environment and society) by:

1. Providing potential targets for mineral exploration (e.g., Xie and Ren, 1993; Wang *et al.*, 1999),
2. Helping determine the baseline state of the environment (e.g., Shacklette and Boerngen, 1984; Reimann *et al.*, 1998; Jiaxi and Wu, 1999; Reimann *et al.*, 2003) from which future changes can be assessed,
3. Contributing valuable information to help develop more informed environmental policies, and
4. Providing information for geohealth studies by gaining knowledge of zones of natural enrichment and depletion, and zones of man-made contamination.

To create reliable geochemical baselines studies, 'normal' (background) sites (Reimann and Garrett, 2005), rather than sites near known mineralisation (e.g., Lech *et al.*, 2003) or anthropogenic interference (e.g., Reimann *et al.*, 1998) should be sampled.

2.2 Groundwater chemistry

Groundwater is in contact, and interacts, with mineral, organic and amorphous matter below the ground surface, and can, as a result, have its chemical or isotopic composition altered. Because it also generally moves in the subsurface, groundwater can 'sample' a variety of minerals along its flowpath, potentially generating a chemical make-up that reflects lithologies and/or mineralisation encountered at depth. Thus, in terms of geochemical exploration, groundwater is a sampling medium that can represent a fairly large volume of rock and have a chemical footprint far exceeding that of, say, a core sample.

Groundwater geochemistry has been used in mineral exploration for a number of years. It was particularly popular in the 1970's (Taufen, 1997), when it was commonly applied to U exploration

(Clarke and Kugler, 1973; Dean *et al.*, 1983; Earle and Drever, 1983; Miller *et al.*, 1984). Hydrogeochemical exploration has experienced renewed interest in the last few years (Giblin and Mazzucchelli, 1997; Leybourne *et al.*, 1998; Pauwels *et al.*, 1999, 2002; Caritat *et al.*, 2001, 2005; Sader *et al.*, 2003), and is likely to become more and more popular as technological developments and increasing affordability continue and the drive to exploration under cover persists.

The advantages of hydrogeochemistry in exploration through thick regolith are that:
(1) groundwater is a medium that has the potential to have been in direct contact with mineralisation;
(2) groundwater is relatively easily and cheaply retrieved and analysed with high-performance equipment;
(3) mineralisation may be located either in the basement rocks (e.g., fractures, alteration zones around VMS or vein-type deposits) or within the cover sequence (e.g., MVT deposits, U roll-front deposits);
(4) exploration is not model-driven (sampling points are, in the most part, where pastoralists have drilled water bores, not where geophysics reveals 'blobs'); and
(5) exploration is not commodity specific (multi-element analysis may reveal unexpected element accumulations).

If the groundwater has interacted with mineralisation at depth, it will have changed major, minor, trace element and/or isotope character. If such geochemical signature is preserved and transported long enough to reach a bore from which groundwater can be sampled, then there is potential for this medium to be very useful in mineral exploration. A hydrogeochemical exploration survey based on previously existing sampling points (bores, wells, springs, seepages) is likely to be of regional usefulness only at first, unless the density of such points is relatively high. Once a sub-area has been identified by hydrogeochemistry as having a high potential to host a blind ore deposit, more detailed (and expensive) exploration tools, such as drilling, can be focused on this much smaller area, thus enabling potentially huge cost savings.

2.3 Aims

The geochemical survey of the Gawler region aims to:

1. Provide an internally consistent, background geochemical dataset for the Gawler region of South Australia,
2. Help develop a suitable geochemical sampling methodology that can be adapted for baseline geochemical studies across Australia, and
3. Enhance global attractiveness to mineral exploration, and improve our resource management and environmental protection in the region.

2.4 Regional setting

2.4.1 Location

The Gawler geochemical survey study area encompasses all the catchments sampled for outlet sediments. It is located to the north of Wudinna and northeast of Ceduna in South Australia and covers 53,636 km^2 (Figure 1).

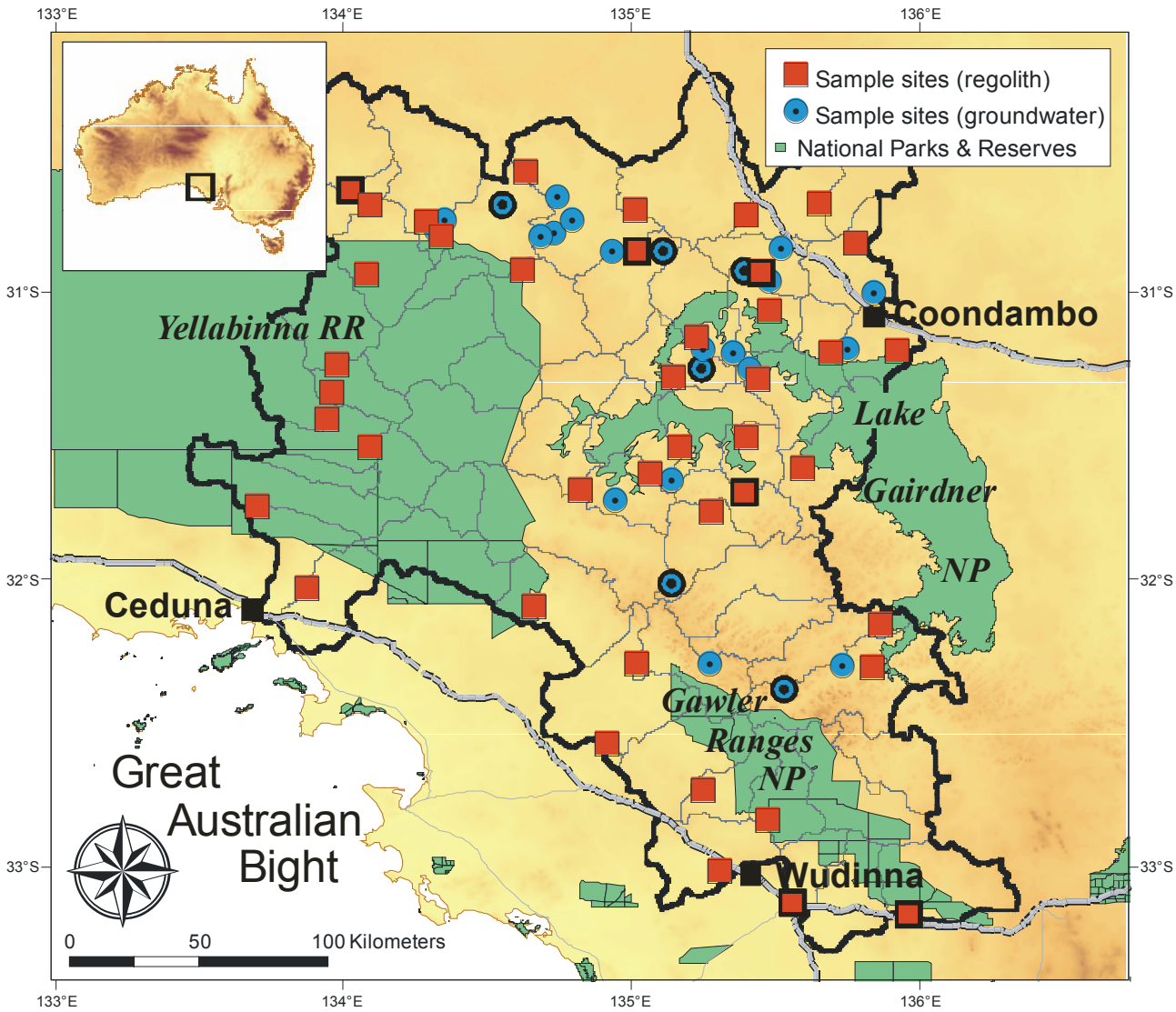
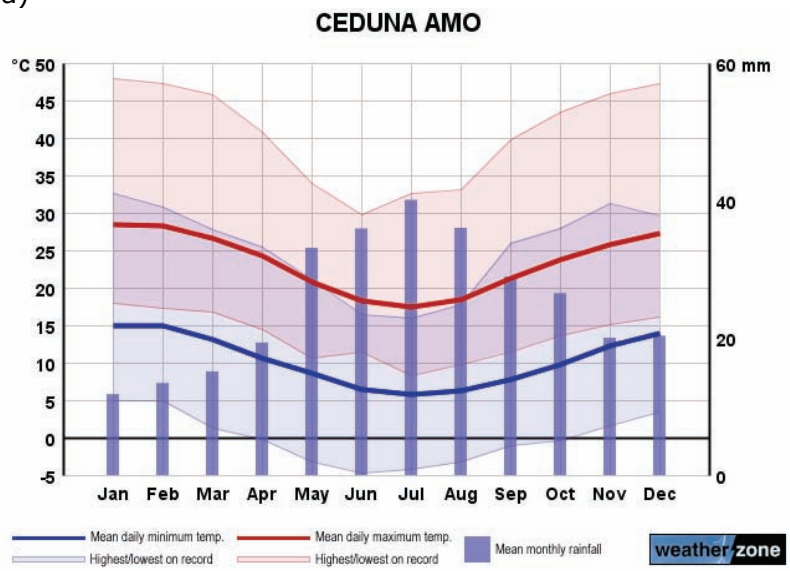


Figure 1. Location of the study area in South Australia and sampling sites for the Gawler geochemical survey (symbols with bold outline were collected during the Reconnaissance trip, the others during the Main trip, see below). Individual catchments are shown in grey, and the outline of all sampled catchments is shown as a bold black line (study area).

2.4.2 Climate

The climate over the Gawler region varies from the wetter coastal areas to the more arid inland areas. Average annual rainfall over the study area ranges from ~100 to 300 mm/yr (BOM, 2005). The northern portion of the area is arid and classified as having low rainfall while the southern portion has winter dominated rainfall and low summer rainfall. In Ceduna, the closest weather recording station, rain falls dominantly over the winter months (Figure 2, Table 1). The temperature in the area is hot in summer and cold-mild winters, sometimes dropping below zero at night.

a)



b)

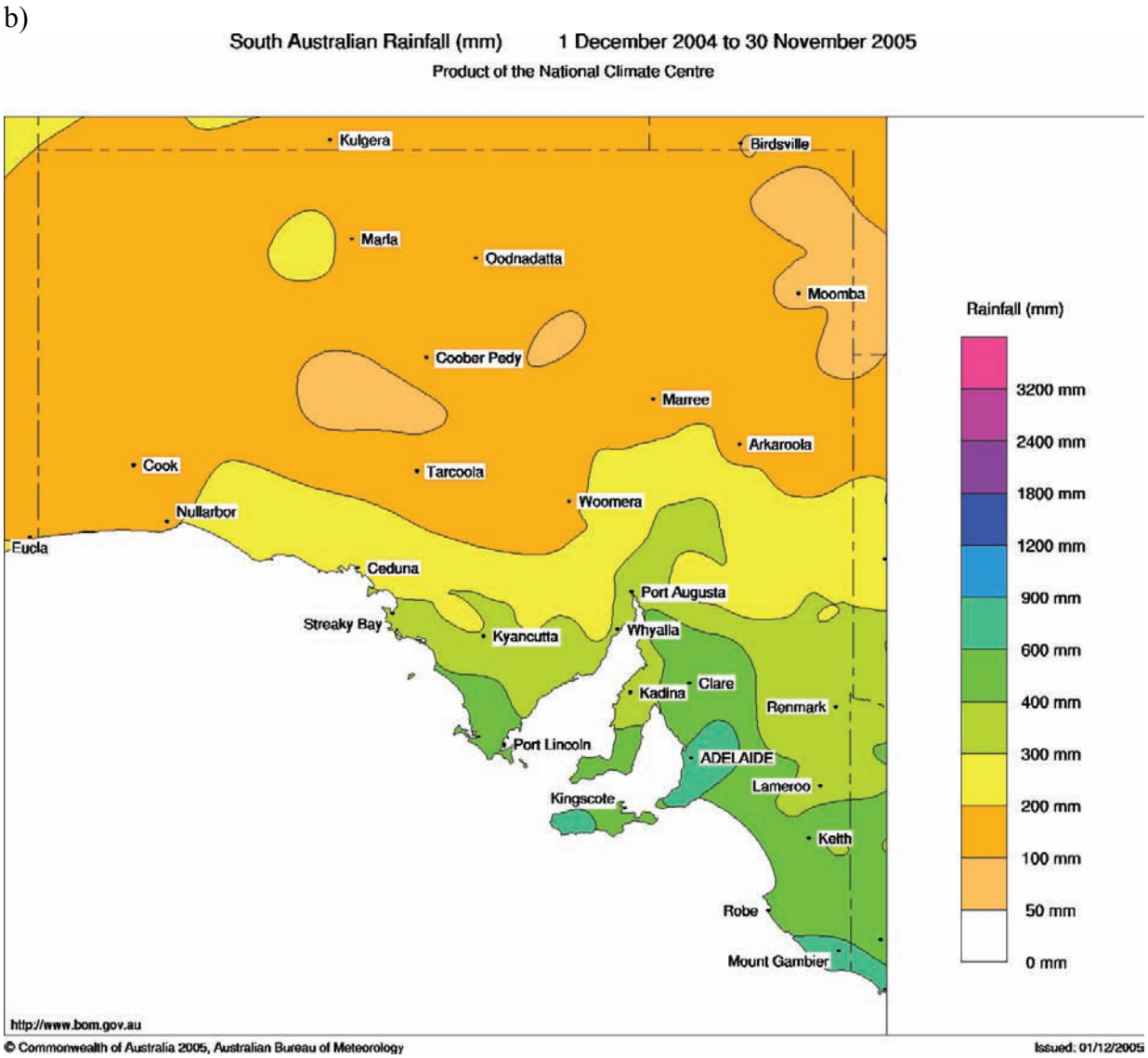


Figure 2. Average temperature and rain fall monthly distributions in Ceduna (a), and cumulative rainfall patterns in South Australia over the 1 year period from 1 December 2004 – 30 November 2005 (b). Source: WeatherZone (2005); BOM (2005).

Table 1. Climate statistics for Ceduna, Tarcoola and Kimba in South Australia. Source: BOM (2005).

Climate averages for Station: 018011 CEDUNA POST OFFICE, SA
Commenced: 1906; Last record: 1990; Latitude (deg S): -32.1267; Longitude (deg E): 133.6725

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	No.of years	% complete
Mean daily max temp (ºC)	27.5	26.3	26.4	23.2	20.2	17.8	16.9	18.6	21	22.7	24.4	26.6	22.6	11.9	98
Highest daily max temp (ºC)	47.2	43.9	43.3	37.8	31.7	26.7	28.3	30	38.3	40	41.7	42.8	47.2	11.1	91
Mean daily min temp (ºC)	15	15.2	13.4	10.6	8.7	6.4	6.2	6.8	8.2	9.9	12.2	14.1	10.5	11.8	97
Lowest daily min temp (ºC)	7.2	5.6	5.6	3.3	-1.1	-2.8	-1.7	-3.9	-0.6	0.7	3.9	5	-3.9	11.1	91
Mean monthly rainfall - mm	7.9	15.5	17	19.3	35.6	38.1	39.5	36.5	24.6	23.1	19.9	15.1	292.1	84.3	100
Mean no. of raindays	2.1	2.3	2.9	5	9.4	10.2	11	9.9	7.5	5.8	4.4	3.2	73.8	71.4	85

Climate averages for Station: 016044 TARCOOLA , SA
Commenced: 1903; Last record: 1999; Latitude (deg S): -30.7111; Longitude (deg E): 134.5694

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	No.of years	% complete
Mean daily max temp (ºC)	35	34.5	31.7	26.4	21.8	18.4	18.2	20.2	23.9	27.5	30.9	33.5	26.8	71.5	92
Highest daily max temp (ºC)	48.5	47.9	45.7	40.5	34	29.1	30.7	33.4	39.7	45	47.9	47	48.5	37.1	98
Mean daily min temp (ºC)	17.9	17.9	15.5	11.2	7.9	5.2	4.2	5.3	8.1	11.2	14.1	16.5	11.2	71.3	92
Lowest daily min temp (ºC)	6.5	8.7	6.1	1.8	-1.4	-3	-4.8	-2.2	-0.6	1.8	4.5	7	-4.8	37	97
Mean monthly rainfall - mm	10.2	21.1	11.4	9.6	16.1	16.8	12.8	15.7	14.7	17.1	14.1	14.2	173.7	92.3	97
Mean no. of raindays	2.1	2	2	2.3	4.4	4.8	4.9	4.5	3.8	3.8	3.4	2.7	40.6	90.1	94

Climate averages for Station: 018040 KIMBA, SA
Commenced: 1920; Last record: 2004; Latitude (deg S): -33.1394; Longitude (deg E): 136.4209

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	No.of years	% complete
Mean daily max temp (ºC)	31.2	31.1	27.8	23.9	19.3	16.1	15.6	16.8	19.9	23.5	26.8	29.1	23.7	35.3	96
Highest daily max temp (ºC)	45.6	44.1	42.3	36.5	29.8	24.7	27	29.1	34.7	38.9	43.2	42.8	45.6	36.5	100
Mean daily min temp (ºC)	15.5	16.2	13.9	11.1	8.2	5.9	4.9	5.4	7	8.9	11.8	13.9	10.4	34.3	94
Lowest daily min temp (ºC)	5.3	7.7	4.3	0.6	1	-0.8	-1.7	-0.8	-1.1	0.4	2.5	4.6	-1.7	36.4	99
Mean monthly rainfall - mm	17	20.9	16.2	22.1	35.9	40.2	41.7	42.6	37.2	31.8	23.9	19.4	348.9	83.6	100
Mean no. of raindays	3	2.9	3.1	5.4	9.3	10.7	12.8	13.4	9.6	7.7	5.3	4	87.2	63.6	76

2.4.3 Geology, regolith and geomorphology

The following outline is adapted from Ferris *et al.* (2003). The Gawler Craton is an ancient crystalline shield comprising Archaean to Mesoproterozoic metasediments, volcanics and granites, which has been tectonically stable, with the exception of minor movements, since ~1450 million years ago (Ma) (Thomson, 1975; Parker, 1990, 1993). Due to very sparse bedrock outcrop, the geology of the Gawler Craton is poorly known, compared to other cratonic areas within Australia. The surface geology of the region is presented in Figure 3. The Craton records crust formation and tectonothermal events in the late Archaean to early Palaeoproterozoic (Sleafordian Orogeny), Palaeoproterozoic (Kimban Orogeny), and Palaeoproterozoic to Mesoproterozoic (Kararan Orogeny). The craton hosts a range of mineralisation, including Au in the central area, a major Fe-oxide Cu-Au province along the eastern edge (Olympic Dam), Ag-Pb-Zn on the eastern Eyre Peninsular as well as REE and heavy mineral sands. Figure 4 shows the tectonic domains of the Gawler Craton and Figure 5 shows the interpreted subsurface geology of the area. Figure 6 shows a close-up of the solid geology in the study area and also shows the location of the regolith sampling sites compared to geological polygons.

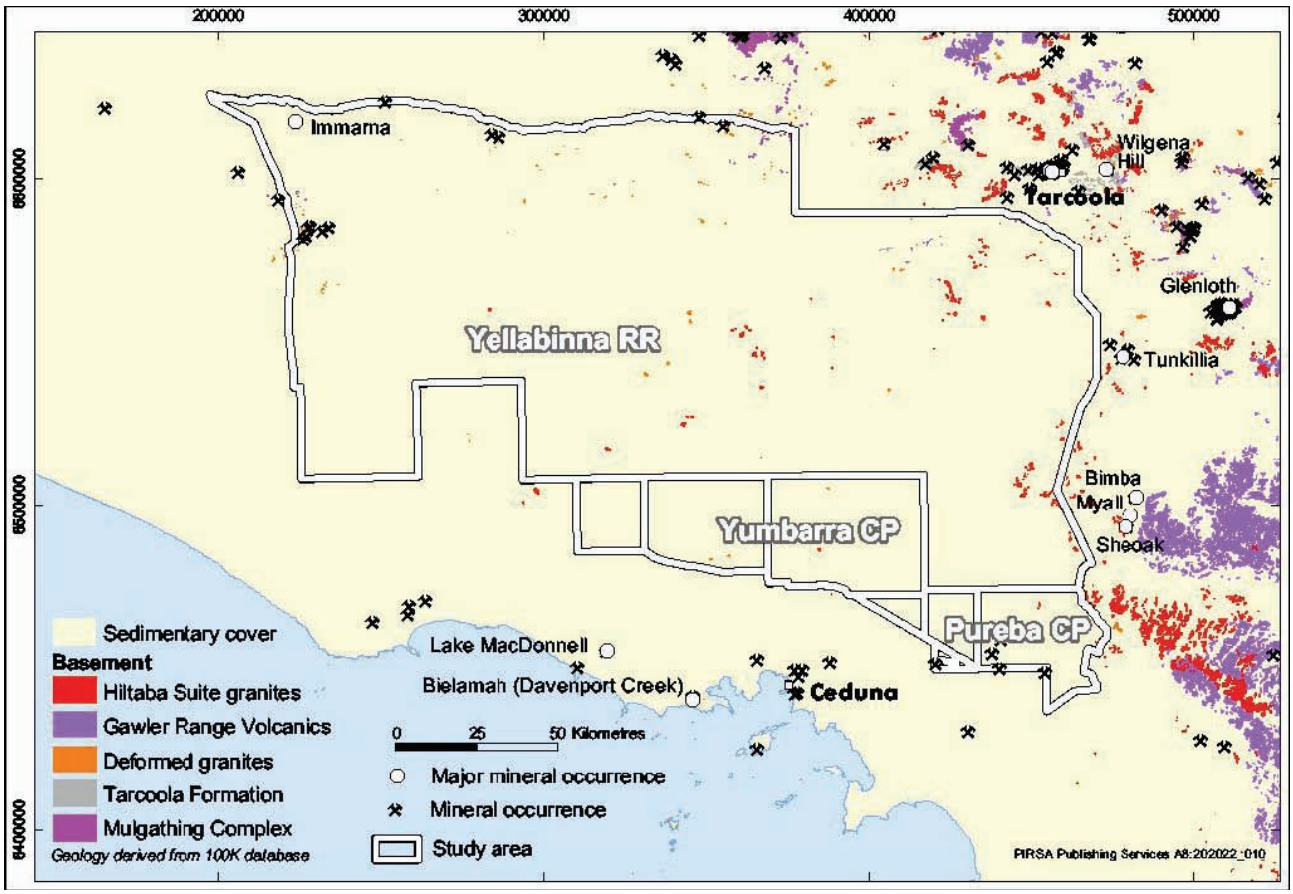


Figure 3. Surface geology of the Gawler region (Ferris *et al.*, 2003). White outline shows location of Yellabinna Regional Reserve, Yumbarra and Pureba Conservation Parks and smaller Conservation Reserves.

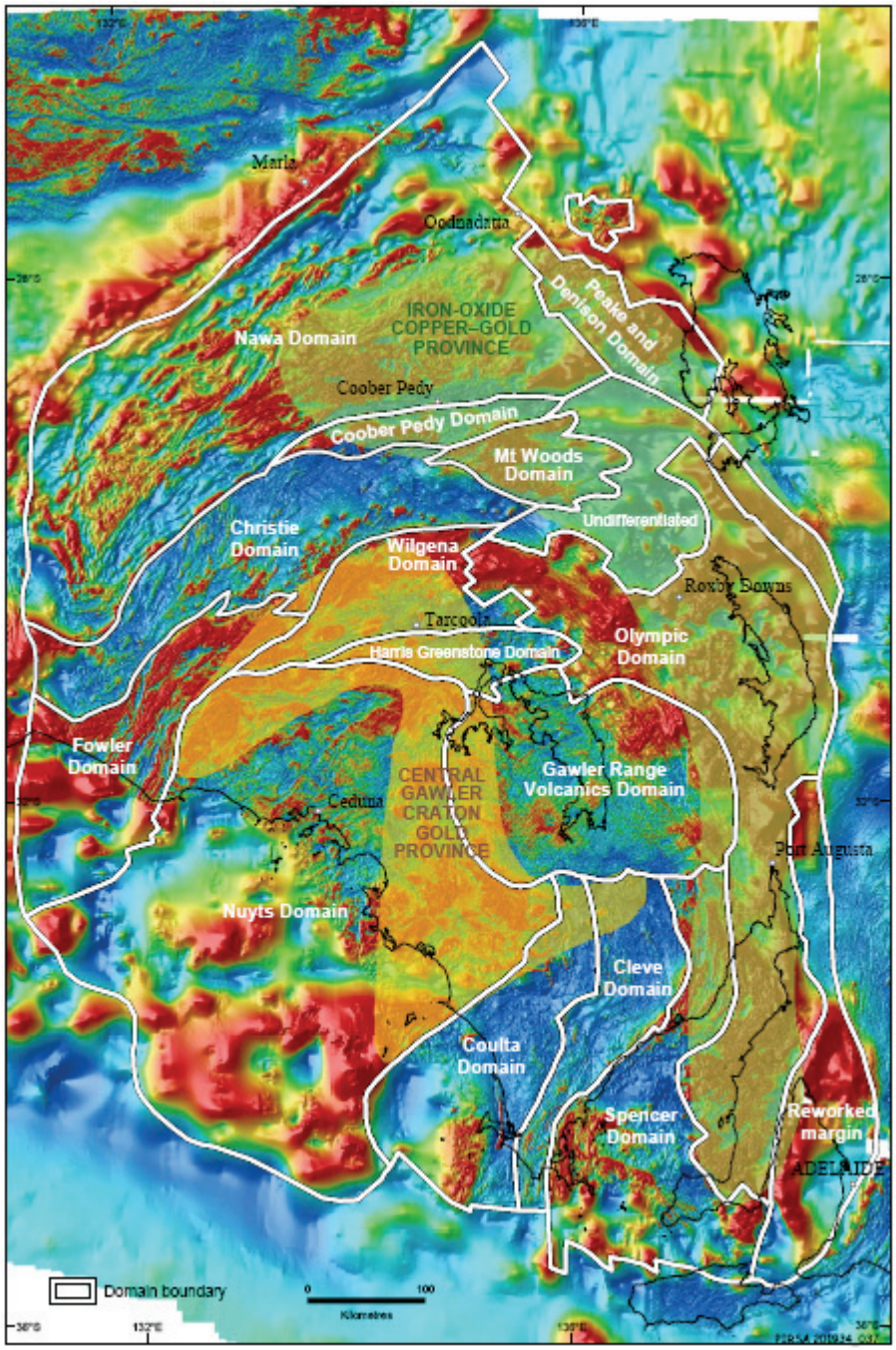


Figure 4. Tectonic domains of the Gawler Craton (Ferris *et al.*, 2003).

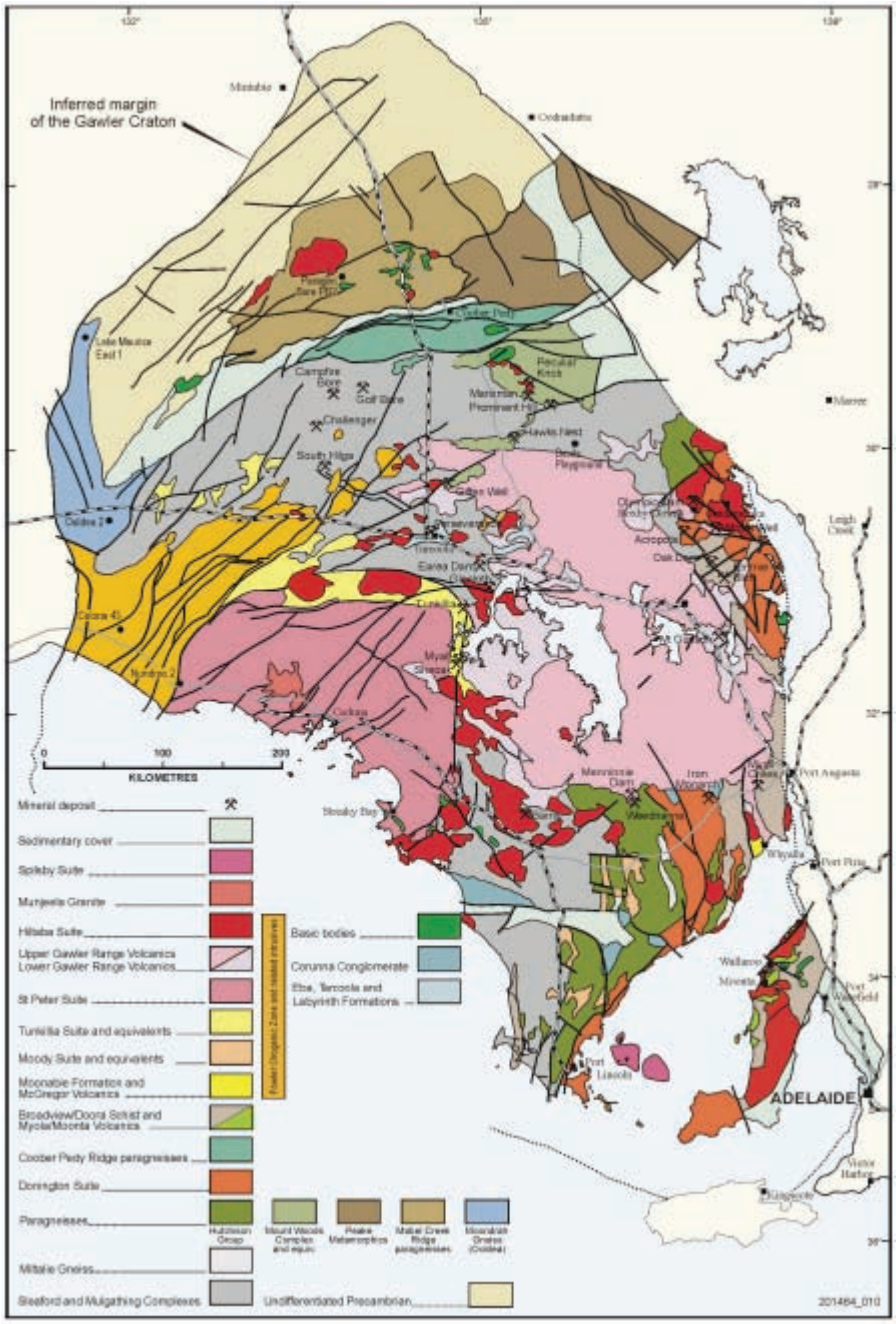


Figure 5. Interpreted subsurface geology of the Gawler Craton, South Australia (Ferris *et al.*, 2003).

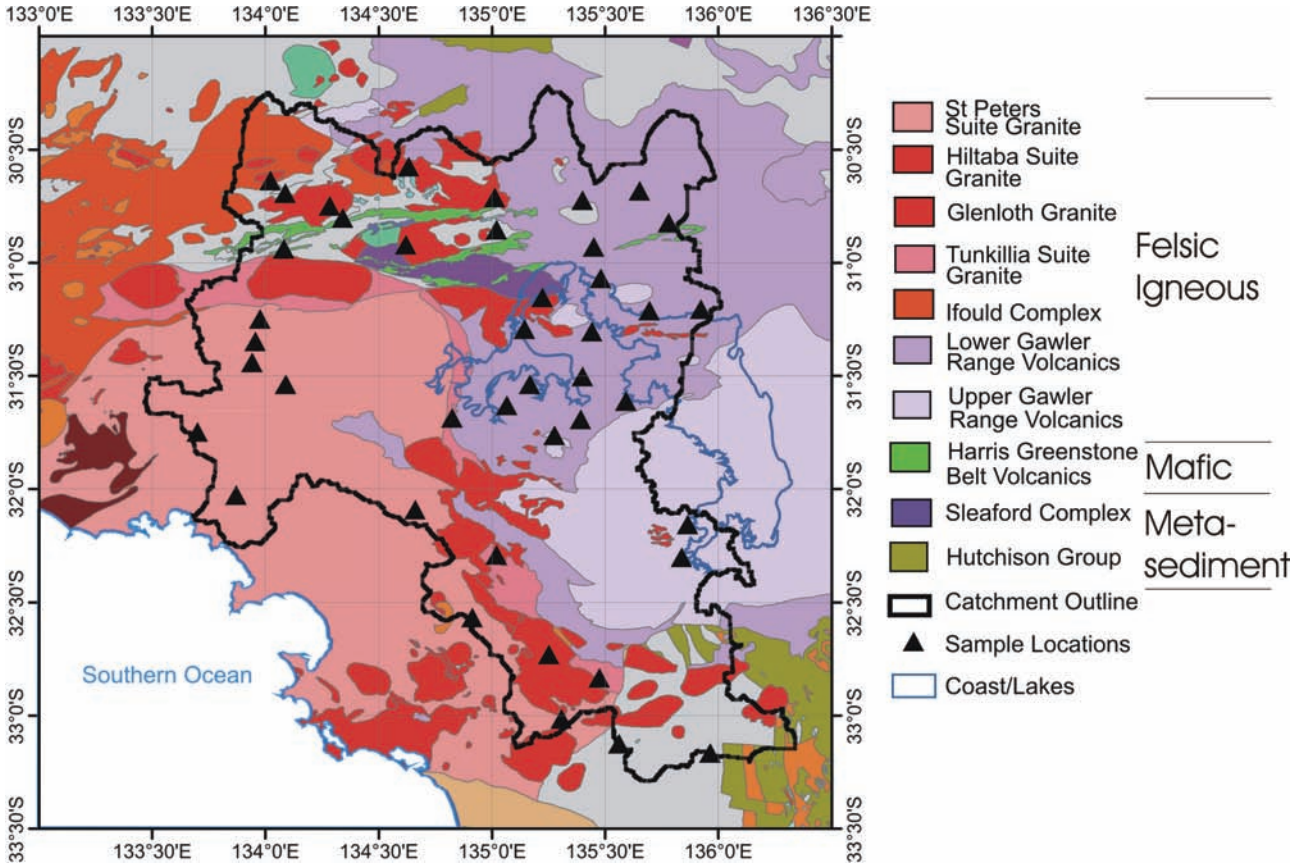


Figure 6. Solid geology with regolith sampling sites overlain (Ferris *et al.*, 2003).

Geomorphologically, the area generally has low relief: elevations range from 0 m along the coast, to ~120 m for Lake Gairdner, to ~460 m for the peaks in the Gawler Ranges (Figure 7). Surface materials comprise dominantly terrestrial alluvium, desert dune fields, some highlands and plateaus and limited coastal marine sediments (Figure 8). Regolith characteristics on a regional Gawler Craton scale have been well discussed in The South Australian Regolith Project Final Report – Summary and Synthesis (Lintern, 2004). There has also been extensive work on palaeoenvironmental reconstructions and palaoechannel characteristics and mapping (e.g., Benbow *et al.*, 1995; Alley *et al.*, 1999; Hou *et al.*, 2001a,b).

A significant portion of the western part of the study area is national park, hence our sampling program was limited to formed dirt tracks through the park and along the dog fence. The rest of the region is dominated by sheep grazing on large stations. Several mineral prospects dot the area including Tarcoola, Tunkillia and Barnes.

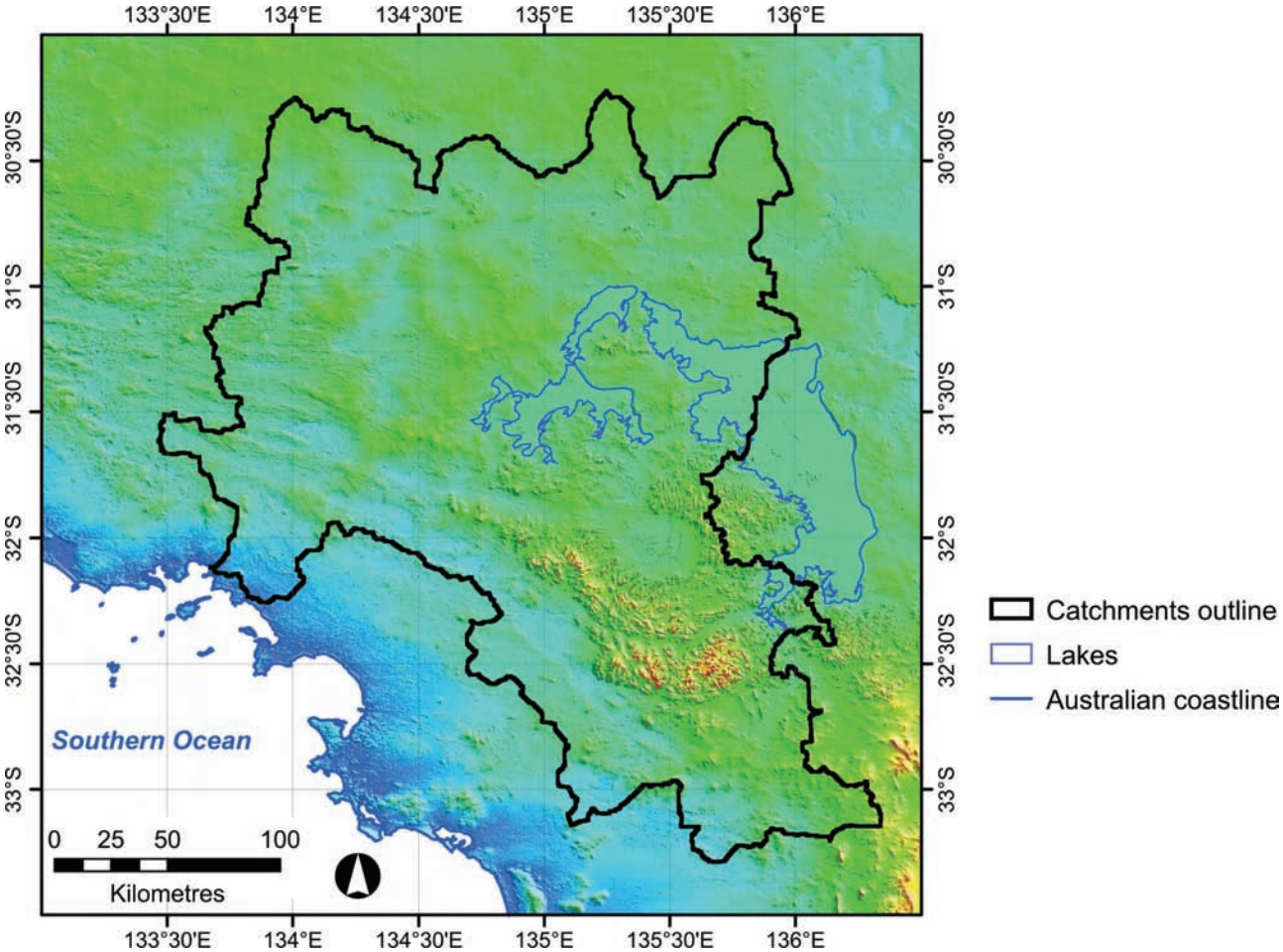


Figure 7. Digital elevation model of the study area (GEODATA 9 Second Digital Elevation Model (DEM-9S) Version 2 (ANZLIC unique identifier: ANZCW0703005624)). Elevations on this map range from 0 to ~480 m asl.

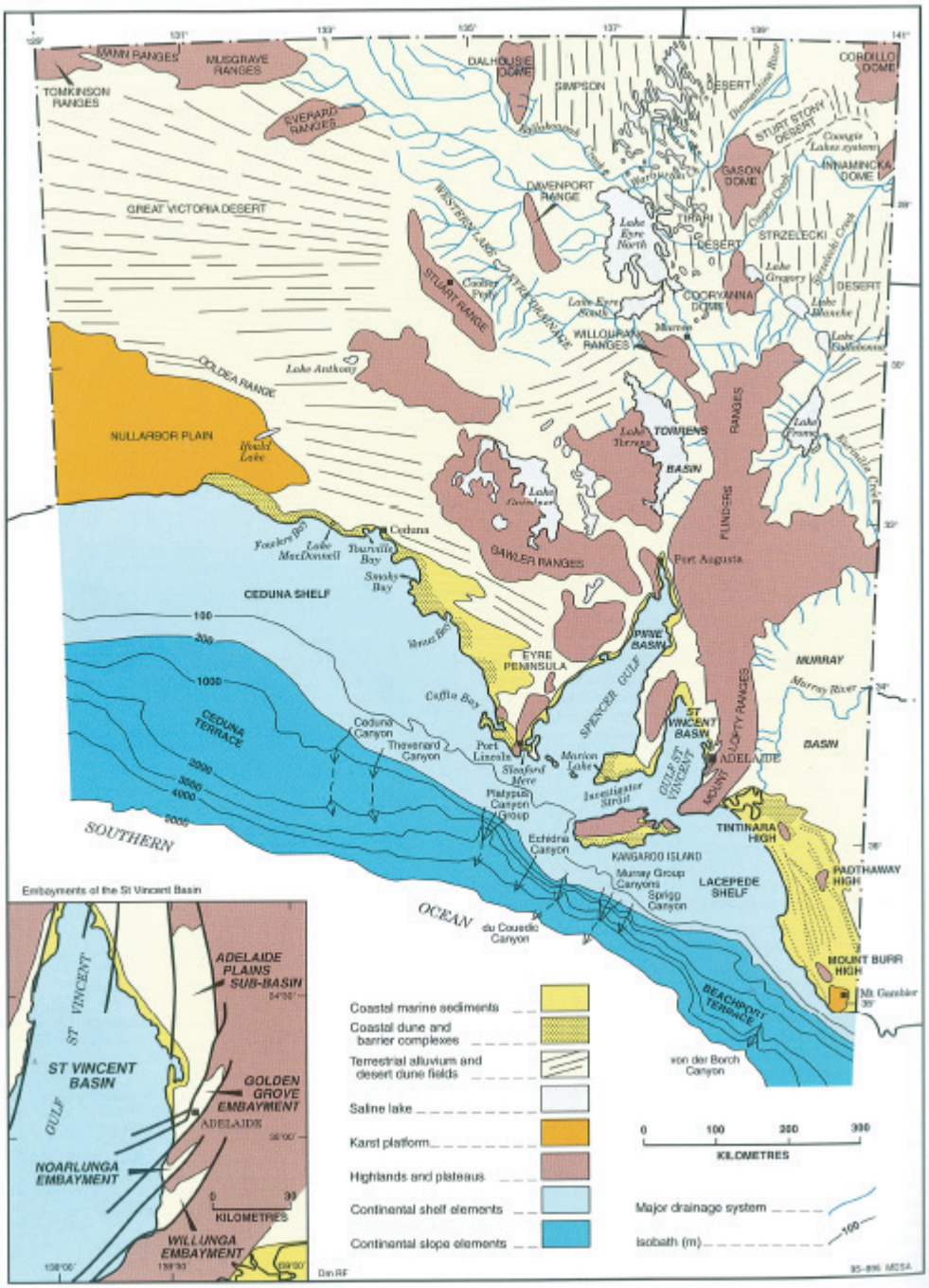


Figure 8. Quaternary morphological elements of South Australia (Belperio, 1995).

3 METHODS

3.1 Selection of sampling medium

The strategy of baseline geochemical sampling during the Gawler project was to target overbank sediments. The rationale behind this sample selection is that the majority of Australia is covered by regolith, much of it transported. Thus by avoiding *in-situ* regolith or bedrock, the sampling medium would be most likely to be found in many environments around the country (but not all). Overbank sediments are an ideal sampling medium because they are present in most environments (compared to stream sediments) and they are more likely to represent the whole drainage basin (Bølviken *et al*., 2004). Indeed, by their very nature, overbank sediments represent well-mixed composite samples of major rock and soil types present in the catchment, and are thus a particularly appropriate choice of sampling medium for low-density geochemical surveys, which aim to represent large tracts of land, as accurately as possible, with as few samples as possible. An additional advantage of these sediments is that, by virtue of being deposited at times of flooding in low-energy environments, they are fine-grained and thus are more likely to be characterised by high signal-to-noise ratios for many chemical elements. Further, the natural stratification of floodplain sediment may yield information relating to past condition by collecting deeper samples, which can be particularly useful in investigating impact of historic changes (Ottesen *et al.*, 1989; Bølviken *et al*., 2004). Because regolith material found in low-lying areas near the outlet of catchments will not always consist solely of overbank sediments, due for instance to the predominance, in places, of aeolian sediments, the general term used to describe the sampling material in its most general form here is 'outlet sediments'.

The main sampling media targeted was outlet sediments, with two ~10-cm intervals sampled: one in the O horizon from 0 to 10 cm below root layer, if present (top outlet sediment, TOS), and another in the B-C horizon at depths generally ranging from 60 to 90 cm (bottom outlet sediment, BOS). For each interval, two bags of ~3-4 kg of material were collected.

3.2 Site selection

The Gawler region was chosen as the focus for this pilot project because it was perceived that the scarcity of active, well-defined drainage systems, combined with the generally low-relief topography and the presence of aeolian landforms and materials, posed a challenge to geochemical mapping. If the methodology proposed in this and earlier pilot geochemical surveys could be shown to deliver meaningful geochemical maps in the Gawler, then most likely it could successfully be applied to the rest of Australia.

3.2.1 Theoretical determination of sampling sites

Because of the nature of the main sampling medium selected, overbank sediments, the landscape units of interest here are hydrologic catchments. Before going out in the field, theoretical (target) sampling sites near the outlet of catchments were established according to the following procedure:

- Datasets used:
    - GEODATA 9 Second Digital Elevation Model (DEM-9S) Version 2 (ANZLIC unique identifier: ANZCW0703005624)
    - Australian Nested Catchments and Sub-Catchments at 500 km^2 scale (ANZLIC unique identifier: ANZCW1202000005) produced in 2000 by the Centre for Resource and Environmental Studies (CRES), Australian National University, Canberra (Hutchinson *et al*., 2004)

- The lowest point (outlet) of each catchment was determined by hydrological analysis using the ArcHydro® v 1.1 Beta 2 extension of ESRI's ArcGIS 8.3® software (Whiteaker and Maidment, 2004).
- Using ArcHydro®, the DEM was filled and flow direction and flow accumulation analyses were conducted. Finally drainage point processing was conducted to determine outlet points. Details for installation and operation of the ArcHydro extension of ArcGIS, and the reduction in the number of sampling points are detailed in Appendix 1.

The target sites established using this technique are not on a uniform grid as their position and distribution are controlled by the regional drainage systems.

All theoretical sampling sites were carefully checked with topographic, drainage and road coverages to see if the locations were reasonable and likely to generate the information sought. Where necessary, the sampling sites were moved from the software-generated ('theoretical' or 'target') position to manually selected locations before going in the field.

3.2.2 General criteria for in field site selection

Once a field party arrived near the target sampling site, the final site locations were decided by considering local landscape, likely anthropogenic interferences, and pragmatic considerations (e.g., access) to finalise where the holes were to be augered based on the following criteria:

- Sampling was to be carried out at a representative location (avoid those sites that are atypical of the location)
- Sampling was to be carried out upstream of roads, bridges, fences, buildings and dams
- To avoid contamination, samples were to be collected at least:
    - 200 m upstream/upslope of roads (particularly major roads)
    - 100 m upstream/upslope of buildings
    - 50 m upstream/upslope of fields
    - 5 m upstream/upslope of fences
- Sites that were obviously disturbed by human activities such as camping (e.g., presence of fire places, cans and/or bottles), grading, mining, landfills, rehabilitated sites, etc. were avoided
- Sampling near or within an open cluster of established (mature) trees was recommended to insure that the land surface was at 'natural' level (no massive recent erosion, no major land rehabilitation or levelling)
- Access permissions to private land, national parks and reserves were to be obtained prior to sampling. Otherwise, sample sites were moved slightly upstream, bearing in mind the size of the catchment being sampled
- Where defined creeks were present, the floodplain/overbank sediments were to be sampled (not the channel sediments)
- In sand dune dominated terrain where no creeks are present, still sample at the lowest point in the catchment in the swale of a dune, where the finer grained sediments and clays accumulate. It is becoming clear that most dune systems in Australia are fairly stationary and well vegetated (Fitzsimmons, 2006; Sheard *et al*., 2006). A study by Sheard *et al*. (2006) found that the sand dunes in the Great Victoria Desert have been stable for about 70 ka and secondary migration of Au into the dune occurred within 10-20 ka. This indicates that dune swales are an appropriate sampling location where overbank sediments are absent.

General comments for sample collection:

- Sampling teams were mindful of contamination by sunscreen, watches, jewellery such as rings and cross-contamination by dirty augers, shovels, etc. Such contamination was easily avoided by wearing gloves (e.g., non-coloured leather) while handling the sampling material or by using a plastic (rather than metal) scoop to collect the TOS sample, and by 'conditioning' the digging tools with the soil at the site to remove traces of soil from previous site
- Sampling teams took measures to preserve the selected site until the sample was taken (i.e., avoiding driving or walking over the area to be sampled)
- Sampling teams refilled all holes and restored the surface to pre-existing conditions as much as possible

3.3 Sampling protocols—Regolith

The fieldwork for the Gawler geochemical survey took place in two phases (Figure 1):

- Reconnaissance trip: 29 October to 5 November 2004 (Patrice de Caritat, Megan Lech, Amy Kernich of GA with Michael Schwarz, John Keeling and Malcolm Sheard of PIRSA)
- Main trip: 27 April to 13 May 2005 (Patrice de Caritat, Megan Lech, Amy Kernich)

3.3.1 Sample collection

3.3.1.1 Sampling of the TOS

The instructions used for the collection of the TOS sample read as follows.

- Remove vegetation and organic litter, and scrape off the root layer (if any) over an area of ~50 x 80 cm.
- Loosen the soil down to 10 cm depth with a shovel over an area of ~30 x 60 cm.
- Label two sample bags and one calico bag with a black permanent marker.
- With a white plastic scoop, collect the 0-10 cm sample interval into 2 sample bags, evenly distributing the sample interval between both bags. Collect a minimum of ~3 kg of sample in each bag.
- For sites with higher clay content and hard, dry sediments, break up the material with a steel crowbar before scooping it up. It is possible that some samples may experience minor contamination from (blue) paint flakes coming off the tool. This is not considered to be a significant concern (the paint was analysed and shown to mostly consist of Ti).
- Fold down several times the top of the bags and staple twice at the top.
- Place the two like (e.g., TOS) samples in the labelled calico bag and close with tie string.

3.3.1.2 Sampling of the BOS

The instructions used for the collection of the BOS sample read as follows.

- With a power or hand auger drill at least 3 holes to ensure a sample representative of the location is taken.
- Once the hole is at the required starting depth (at least 50 cm), clean out the inside of the hole with a gloved hand to ensure no wall or surficial material is collected
- Label two sample bags and one calico bag with a black permanent marker.
- With a clean hand auger, collect the regolith material and place into the sample bags. As with the TOS, collect a minimum of ~3 kg of sample in each bag

    - To ensure the sample is a composite, collect alternatively from each of the holes, ensuring that each bag has a mix of materials from all holes over the sampled depths.
    - On rare occasions when the sediment can not be retrieved with the hand auger (e.g., to loose or too hard), it can be carefully loosened (but not brought to the surface) with the power auger and collected by reaching down the hole with a gloved hand.
- Where the soil is too hard for power or hand auger combinations, dig a small trench (~50 cm wide and between 70 and 150 cm long) to the desired depth using a shovel and crowbar
    - Collect the disaggregated material from several locations across the trench floor with a white plastic scoop.
- At locations where hardpans (e.g., carbonate) are encountered at or before reaching the target sample depth, collect samples from auger holes above the hardpans to avoid secondary modifications of the sampling medium sought.
- Fold down the top of the plastic bags several times and staple twice at the top.
- Place the two like (e.g., BOS) samples in the labelled calico bag and close with tie string.

Two different hand augers (3 inch diameter) and a mechanical auger (posthole digger; 6 inch diameter) made of tool steel, a shovel and crowbar were used during fieldwork in this project.

3.3.2 Sampling equipment

The equipment used for collection of samples was as follows:

- Shovel
- Crowbar
- Tanaka JEA-50 petrol driven power auger with 6 inch bit
- 2 hand augers
- Paper field sampling forms
- Large screwdriver (for scraping caked soil off auger, if needed)
- Measuring stick
- White plastic scoop
- Leather gloves
- 25 x 35 cm (150 μm thick) plastic sample bags for TOS and BOS
- 30 x 45 cm calico (cotton) bags
- Stapler and staples
- Black markers, pens, pencils
- Field sample forms
- Inoculo™ pH testing kit
- Munsell™ Colour Chart
- RTMAP Redbook
- 10 % HCl (test for soil carbonates) in a 45 mL dropper
- 10 % H_2O_2 (Fe/Mn reaction test) in a 45 mL dropper
- Ear plugs, dust masks

3.3.3 Field measurements

For the Gawler project, texture, pH and Munsell™ soil colours were determined in the field for each sample. The standard procedures used are described in the following sections.

3.3.3.1 Munsell soil colour

Soil colour reflects an integration of chemical, biological and physical transformations and translocations that have occurred within a soil [http://www.soils.wisc.edu]. In general, colour of surface horizons reflects a strong imprint of biological processes, notably those influenced by the ecological origin of soil organic matter (SOM), which imparts a dark brown to black colour to the soil. Generally, the higher the SOM content of the soil, the darker the soil. A bright/light colour can be related to an eluvial horizon, where sesquioxides, carbonates and/or clay minerals have been leached out.

Subsoil colour reflects more strongly in most soils the imprint of physico-chemical processes. In particular, the redox status of Fe and to a lesser extent Mn, strongly influence the wide variation found in subsoil colour. Soil colour can provide information about subsoil drainage and moisture conditions. The colours of the Fe oxides and hydroxides are indicative of redox conditions. In well aerated soils, Fe^{3+} is present and gives soil a yellow or reddish colour. For instance, Pell *et al.* (1999) found that soils in the Great Victoria Desert range in colour from yellow in the south grading through to red in the north. In more poorly drained soils (anaerobic conditions) iron compounds are reduced and the neutral grey colours of Fe^{2+} or bluish-green colours of iron sulfides, iron carbonates, or iron phosphates are visible. A black colour in the subsoil can be related to an accumulation of manganese.

In arid and semi-arid environments, the influence of soluble salts (carbonates, sulfates, chlorides etc.) may impart a strong influence on soil colour. For example, in arid or subhumid regions, surface soils may be white due to evaporation of water and soluble salts.

Colours associated with minerals inherited from parent materials may also influence colour in horizons that have not been extensively weathered. For example, light grey or nearly white colours are sometimes inherited from parent material, such as marl or quartz. Parent material, such as basalt, can imprint a black colour to the subsoil horizons.

Munsell soil colour was determined in the field using a Munsell™ soil colour chart (Munsell Color Company, 1975) according to standard protocols outlined by Northcote (1979). Moist and dry hue, value and chroma (e.g., 7YR5/4) were recorded on the sampling forms.

Soil colour was determined on a freshly broken soil aggregate held as close as possible to the colour chip. Where soil colour did not match the colour chip, the closest chip colour was used. Care was taken to ensure the broken surface was not smeared as this may produce an incorrect colour of the soil matrix. The aggregate was then moistened and soil colour was recorded once the visible moisture film disappeared from the soil aggregate's surface.

3.3.3.2 Field pH

Field pH provides information that can be related to element mobility and stability within the regolith materials. It can be correlated with various chemical and environmental factors that influence soils and plants. Field pH is a different, though not totally unrelated, measurement compared to lab pH measurements based on various water or chemical extracts. Soil pH, regardless of the way it is measured, can vary markedly within a short distance.

The Inoculo™ Soil pH Testing Kit (Figure 9) designed by the CSIRO Division of Soils was used to determine in-field soil pH measurements as follows:

- A 2 mm sieve was used to sieve out any coarse material
- A teaspoon of soil was placed on a white plastic tray provided in the test kit

- A few drops of the green dye indicator liquid was placed on the soil
- A stick was used to mix the indicator liquid and the soil
- The white $BaSO_4$ powder was lightly dusted over the moist soil
- Although the indicator changes immediately, it was left a few minutes before the colour was matched to the accompanying indicator card to determine the pH value
- The colour chosen should match the dominant colour of the $BaSO_4$ powder

Figure 9. Inoculo soil pH test kit used for the survey.

3.3.3.3 Soil texture

The method and grades of soil texture used are described by Northcote (1979) (Table 2). The soil is progressively moistened with a little water and manipulated until the ball of soil that has formed no longer sticks to the fingers. The ball is kneaded and moistened for a further 1-2 minutes until there is no apparent change in the ball. The ball (bolus) is now ready for texture determination. Its characteristics when sheared between the thumb and forefinger determine its texture. McDonald *et al.* (1990) also recommend the Northcote (1979) scale as standard for soil classification.

Texture provides context as to how and why elements may be concentrated or depleted in the soil, and can be a potential indicator of material origin. Soil texture is a function of grain-size distribution, organic matter content and other parameters. Clays can adsorb and exchange several elements. This is important where multiple material sources (which may influence element dispersion) need to be discriminated (e.g. alluvium vs aeolian material). It may also provide insights into the hydrology of the material, which in turn influences the geochemistry.

Table 2. Soil texture key (after Northcote, 1979). Source: Clarkson (2006).

Texture symbol	Field texture grade	Behaviour of moist bolus	Approx. clay content (%)
S	Sand	Coherence nil to very slight, cannot be moulded; sand grains of medium size; single sand grains stick to fingers.	Less than 5%
LS	Loamy Sand	Slight coherence; sand grains of medium size can be sheared between thumb and forefinger to give minimal ribbon of 5 mm.	Approx. 5%
CS	Clayey sand	Slight coherence; sand grains of medium size; sticky when wet; many sand grains stick to fingers; will form a minimal ribbon of 5-15 mm; discolours fingers with clay stain.	5-10%
SL	Sandy loam	Bolus coherent but very sandy to touch; will form a ribbon of 15-25 mm; dominant sand grains are of medium size and are readily visible.	10-20%
FSL	Fine sandy loam	Bolus coherent; fine sand can be felt and heard when manipulated; will form a ribbon of 13-25mm; sand grains are clearly evident under a hand lens.	10-20%
SCL	Light sandy clay loam	Bolus strongly coherent but sandy to touch; and sandy to touch; sand grains dominantly medium sized and easily visible; will form a ribbon of 2-2.5cm.	15-20%
L	Loam	Bolus coherent and rather spongy; smooth feel when manipulated but with no obvious sandiness or 'silkiness', may be somewhat greasy to the touch if much organic matter present; will form ribbon of 25 mm.	About 25%
Lfsy	Loam, fine sandy	Bolus coherent and slightly spongy; fine sand can be felt and heard when manipulated; will form a ribbon of about 25 mm.	Approx. 25%
ZL	Silty Loam	Coherent bolus; very smooth to often silky when manipulated; will form a ribbon of approx. 25 mm.	Approx. 25% and with silt approx 25% or more
SCL	Sandy clay loam	Strongly coherent bolus, sandy to the touch; medium sized sand grains visible in finer matrix; will form a ribbon of 25-40 mm.	20-30%
CL	Clay loam	Coherent plastic bolus; smooth to manipulate; will form a ribbon of 40-50 mm.	30-35%
CLS	Clay loam, sandy	Coherent plastic bolus; medium sized sand grains visible in finer matrix; will form a ribbon of 40-50 mm.	30-35%
ZCL	Silty clay loam	Coherent smooth bolus, plastic and often silky to the touch; will form a ribbon of 40-50 mm.	30-35% and with silt 25% or more.
SC	Sandy clay	Plastic bolus; fine to medium sands can be seen, felt or heard in clayey matrix; will form a ribbon of 50-75 mm.	35-40%
ZC	Silty clay	Plastic bolus; smooth and silky to manipulate, will form a ribbon of 50-75 mm.	35-40%
LC	Light clay	Plastic bolus; smooth to touch; slight resistance to shearing; will form a ribbon of 50-75 mm.	Clay: 35-40% Silt: 25%+
LMC	Light medium clay	Plastic bolus; smooth to touch; slight to moderate resistance to forming a ribbon; will form a ribbon of 75 mm.	40-45%
MC	Medium clay	Smooth plastic bolus; can be moulded into a rod without fracturing; has moderate resistance to forming a ribbon; will form a ribbon of 75 mm +.	45-55%
MHC	Medium heavy clay	Smooth plastic bolus; can be moulded into a rod without fracturing; has a moderate to firm resistance to forming a ribbon; will form a ribbon of 75 mm or more.	50%+
HC	Heavy clay	Smooth plastic bolus; can be moulded into rods without fracturing; has firm resistance to forming a ribbon; will form a ribbon of 75 mm +.	50%+

3.3.4 Sample numbering

The samples were numbered according to the Geoscience Australia code:

- **2004 851 001 X** to **2004 851 012 X**, for instance for the Reconnaissance trip, with '2004' being the year, '85' the project number, '1' the geologist or team, '001' to '012' the site number (increasing incrementally for each site where regolith or groundwater was sampled) and 'X' the layer/bag (with 'X' = '001' for TOS, '002' for BOS). The site numbers can refer to a regolith sampling site (001, 002, 004, 006, 009, 012) or a groundwater sampling site (003, 005, 007, 008, 010, 011).

- The Main trip regolith sample numbers are **2005 851 101 X** to **2005 851 136 X**, where X was shortened to '1' for TOS and '2' for BOS. To avoid confusion between regolith and groundwater sampling sites, groundwater (and 1 rainwater) samples were numbered **2005 851 201** to **2005 851 220**.

Thus, 6 + 36 sites were visited and sampled for regolith, for a total 42 regolith sites, and 6 + 20 sites were visited and sampled for groundwater, for a total 25 groundwater sites + 1 rainwater sample, #216, from a plastic rainwater tank (Figure 1, Figure 10). The regolith sample density averaged ~ 1 site per 1117 km^2 for the Gawler geochemical survey. Due to the low sampling density adopted for this survey, *local* anomalies in elemental concentration are unlikely to be found due to the dilution/averaging effect of this sampling method.

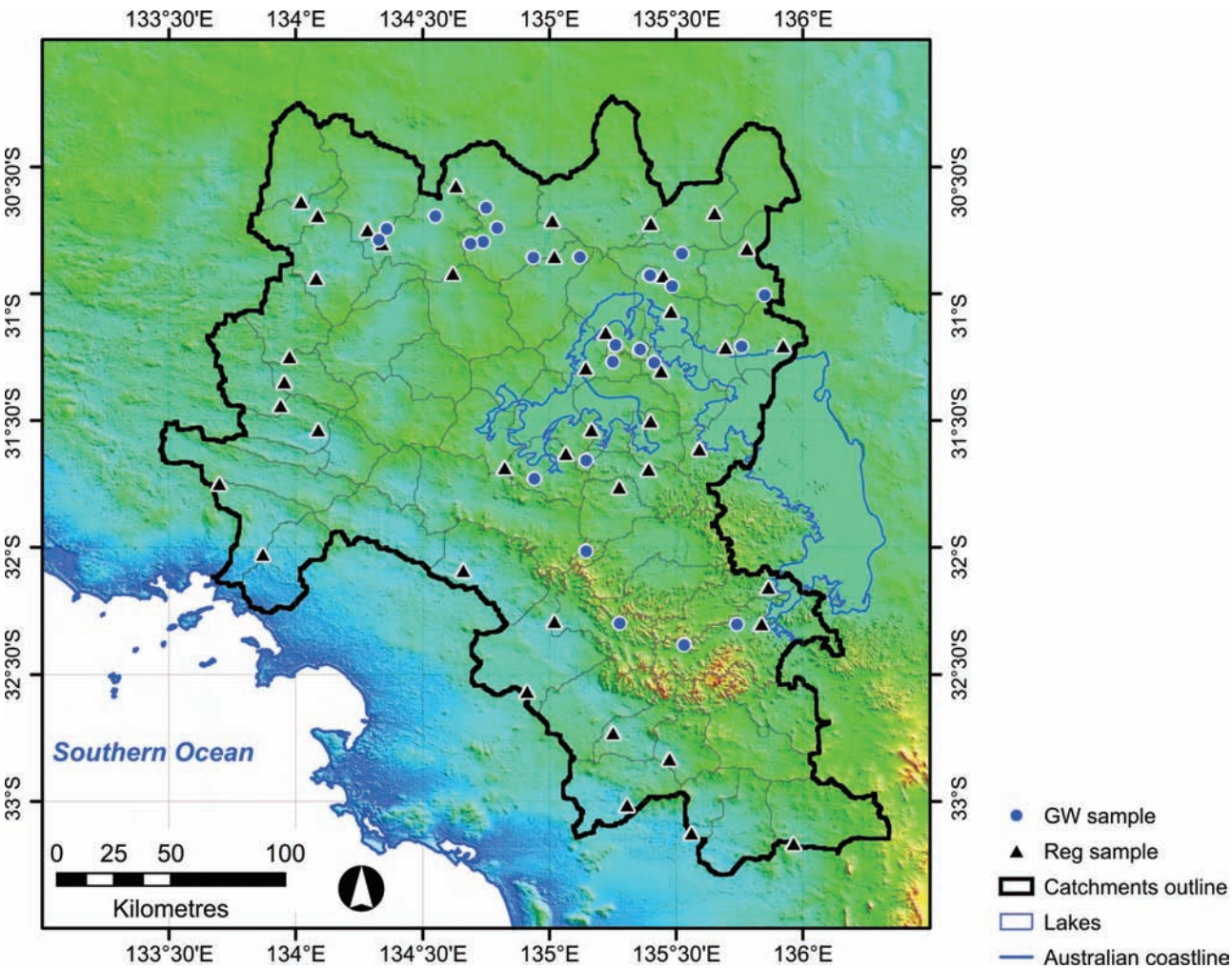


Figure 10. Location of regolith (Reg) and groundwater (GW) sampling sites, together with catchment outlines (grey polygons) overlain on digital elevation model (GEODATA 9 Second Digital Elevation Model (DEM-9S) Version 2 (ANZLIC unique identifier: ANZCW0703005624)).

3.3.5 Field form

At each site, field data was entered on the sampling forms and in the palmtop computer. Some of that data is subsequently entered into Geoscience Australia's RTMAP, FIELD SITES and DEVIANT databases.

A form has been developed (Appendix 2) to record all relevant field information while at the sampling site. The form was modified from Äyräs and Reimann (1995) and Salminen *et al.* (1998) to suit Australian conditions. At each site, the sampling form was filled to record, among others,

date, GPS location, width and flow of the stream or river (if applicable), regolith landscape position, geomorphic processes, field parameters such as texture and Munsell soil colour.

General comments for in-field site documentation:

Field instructions used for this project read as follows.

- Take a close-up photo of the sample bag immediately before the site photos. (This will aid in labelling the photos later)
- Take a photo showing the holes with a shovel down the hole to indicate depth. Take several photos that are representative of the landscape. One of these should be taken showing the river/creek
- Coordinates should be recorded in Geographic Coordinate System, Geodetic Datum of Australia 1994 (GCS GDA94)
- Latitude and longitude to be recorded in decimal degrees
- Use the RTMAP 'red book' (Pain *et al.*, 2007) to determine the landform and geomorphology, using the definitions in the back

3.4 Sampling protocols—Groundwater

Groundwater was sampled from bores and wells (Figure 11), using existing windmills or other pumping system; in a few cases no pumping system was in place (7 samples out of 26), and bailing water from 5-10 m below the standing water level was performed using a 2-inch PVC ball valve bailer. Pumping and water monitoring (for temperature, pH, electrical conductivity, dissolve oxygen and Eh) was performed for a length of time to allow fresh groundwater (recently discharged from the aquifer) to be sampled, rather than stale bore water. These field parameters were recorded during the pre-sampling pumping, at the time of sampling, and in most cases for a short time after sampling. The field electrodes were placed in a flowcell (Figure 11) to minimise or negate contact of the groundwater with the atmosphere. Other parameters recorded in the field were: dissolved reduced iron (Fe^{2+}) and dissolved reduced sulfur (S^{2-}), both by spectrophotometry, and dissolved bicarbonate (HCO_3^-) by titration.

Using non-powdered latex gloves and new containers (all rinsed 3 times with the water to be sampled), the following samples were taken at each groundwater site:

- 125 mL for cations (inductively coupled plasma-emission spectrometry of mass spectrometry, ICP-ES and ICP-MS), filtered 0.45 um (using Pall Supor®-450 membrane filters with nominal 0.45 micrometer pore size and 90 mm diameter) and acidified (1-2 mL ultra pure HNO_3) [high density polyethylene, HDPE, bottle]
- 125 mL for anions (ion chromatography, IC) filtered 0.45 um [HDPE bottle]
- 100 mL amber glass bottle of filtered water for I analysis
- 2 x 15 mL of raw water collected in Vacutainers® for stable isotopes of H and O in water (by mass spectrometry) [glass Vacutainers®]
- 500 ml to 1L for stable isotopes of C and O in dissolved bicarbonate (by mass spectrometry) filtered 0.45 um and stabilised by addition of 1-2 mL NaOH and 10 g $BaCl_2$ (Reconnaissance trip) $SrCl_2$ (Main trip) [HDPE]
- 500 ml to 1L for stable isotopes of S and O in dissolved sulfate (by mass spectrometry) filtered 0.45 um and stabilised by addition of 1-2 mL HNO_3 and 10 g $BaCl_2$ [HDPE]
- 1 L for Au analysis, filtered 0.45 um, acidified (2-3 mL HNO_3), salted (30 g NaCl) and with addition of a clear plastic mesh sachet containing 1 g of activated carbon [HDPE]

Figure 11. Monitoring and sampling groundwater during the Gawler project.

3.5 Sample preparation and analysis

The various regolith sample preparation methods used are described in detail below and summarised in
Table 3.

Table 3. Summary of regolith sample preparation methods used for the Gawler geochemical survey.

Method	Analysis location	Sample 1 (TOS)	Sample 2 (BOS)
Field pH	GA/field	Raw	Raw
Texture	GA/field	Raw M	Raw M
Munsell soil colour (Dry)	GA/field	Raw	Raw
Munsell soil colour (Moist)	GA/field	Raw M	Raw M
EC 1:5	GA	D40 U	D40 U
pH 1:5	GA	D40 U	D40 U
XRF	GA	D40 S180	D40 S180
ICP-MS	GA	XRF bead	XRF bead
Laser Particle size analysis	GA	D40 U	D40 U
Heavy Mineral Fraction	GA	Raw	Raw

Key:		
	Dx	Dried to x °C (see text for duration)
	M	Moist
	Sx	Sieved to x um (micrometer)
	U	Unsieved
	Raw	As found under field conditions

3.5.1 Grain size fractions selection

The bulk samples were dry-sieved to a <180 µm and a <75 µm grain-size fraction for geochemical analysis. The coarser of these fractions was selected because this is the coarsest grain-size that can be prepared for XRF pellets and beads without requiring mechanical grinding (milling). Milling introduces an additional step in the sample preparation process, which is time-consuming (thus expensive) and has the potential to introduce contamination. It was decided that this step was best avoided. Because of the general fine-grained nature of the overbank sediments, however, the <180 µm fraction still represents close to a bulk composition of the samples (see below). Furthermore, this size fraction, equivalent to the -80 mesh fraction, is commonly used in geochemical investigations around the world, allowing comparison with these studies. The finer grain-size fraction was chosen to enhance the signal-to-noise ratio by focusing on the clay + silt content and minimising sample dilution by sand.

3.5.2 Drying and sieving

- For geochemical analysis, the two TOS sample bags were mixed and homogenised. The same was done for the BOS sample.
- The sample numbers were engraved into the bottom of a new 250 x 380 x 50 mm Al baking dish
- Each sample was spread evenly in its dish and dried in an oven at 40 ^{o}C for 48 hours
- The sample was homogenised then riffle split into two portions, one consisting of about one third of the total amount of bulk sample, the other about two thirds. The first portion was sieved using 180 µm (ASTM #80 mesh) nylon mesh, the second using 75 µm (ASTM #200 mesh) nylon mesh. Sieves were cleaned between samples using compressed air
- Clay aggregates (clumps) not passing the sieves were disaggregated by placing them in a 250 x 350 mm plastic bag, rolling the top closed and gently pounding the clumps with a large ceramic pestle. This process was repeated until sufficient sample was obtained, replacing the sample bag as required
- Approximately 80 g of each grain-size fraction of sample was kept for geochemical analyses
- No grinding of the sample was required at all

3.5.3 X-ray fluorescence (XRF) analysis of multiple elements

3.5.3.1 Sample preparation

Glass beads were analysed for all majors and some traces using XRF analysis.

The glass beads were prepared for analysis as follows:

- Accurately weighing approx 0.27 g of sample and 1.73 g of 57:43 (lithium tetraborate:metaborate) flux into a Pt crucible
- Adding 0.5 mL of a 20 % $LiNO_3$ solution to the crucible
- Sintering the mixture in a furnace set at 400 ^{o}C for 10 minutes to oxidise any sulfides present
- Transferring the crucible to the Bradway™ rocking furnace and heat at 1100 ^{o}C for a further 10 minutes
- Adding a few crystals of NH_4I anti-wetting agent to the melt after 8 minutes
- Removing the melt after 10 minutes and quickly quench press on a preheated graphite disc using an aluminium press
- After pressing, annealing the disc on a hotplate at 180 ^{o}C for 20-30 minutes

3.5.3.2 Analysis

XRF analyses were carried out in the Onshore Energy and Minerals Division Laboratory at Geoscience Australia. The laboratory's XRF is a Philips PW2404 4kW sequential spectrometer with a Rh tube. It is used to determine the major elements present in samples presented to the laboratory and a range of the routinely more abundant trace elements to complement those analysed on the ICP-MS (see below).

The instrument is calibrated using a range of USGS and SARM (South African Reference Material) and other international standards. Synthetically prepared standards and some Australian Soil and Plant Analysis Council (ASPAC) standards were also used. The 'Classic Model' as outlined in the 'Philips SuperQ/Quantitative Users Guide' was used to calculate alpha coefficients and line overlap factors.

Reference monitor standard Si3 is used.

The routinely determined major elements are SiO_2, TiO_2, Al_2O_3, Fe_2O_3, MnO, MgO, CaO, Na_2O, K_2O, P_2O_5 and SO_3.

This program uses 57:43 X-Ray flux (57 % Li tetraborate 43 % Li metaborate) because of its ability to fuse a wide range of sample types. It is used for all regolith samples and any samples that may contain significant NaCl. The trace elements Sc, V, Cr, Ni, Cu, Zn, Ba, Cl and F are determined on these fusions because NaCl and other soluble salts migrate to the surface of powder pellets as the binder dries causing gross errors. Generally speaking, the longer the wavelength of the element being measured the worse the error. ICP-MS results are used for all other trace elements (see below).

Loss on ignition (MLOI) is calculated as the difference between the sum of all major oxides as obtained by XRF analysis and 100 %. To correct for the possibility that some of the S in a sample is reduced, the LOI values presented in this report are calculated as %LOI = %MLOI + (0.6*%SO3). The parallel correction for Fe was not undertaken because testing showed that most Fe in the regolith samples was oxidised (see below).

3.5.4 Inductively coupled plasma-mass spectrometry (ICP-MS) analysis of multiple elements

Because of equipment issues, regolith samples from the 6 Reconnaissance trip sites were analysed by ICP-MS at Geoscience Australia, and the remainder of the regolith samples (Main trip) were sent to ACME Laboratories in Vancouver (Canada). The samples preparation methods of these 2 labs are quite different, as reported below, and results can not be compared.

3.5.4.1 Sample preparation at Geoscience Australia

Recent research at Geoscience Australia (Pyke *et al*., 2000) on the best methods for presenting a solid sample to the ICP-MS, especially taking into account the high degree of inter-comparison required between XRF (majors and some traces) and ICP-MS (rest of the traces), has shown that a multi-acid digestion of fragments of the XRF fused beads has many advantages. Therefore, this method was adopted here, and is briefly summarised below:

- Approximately 100 mg of chips from the smashed XRF beads (or discs) are weighed accurately into Savillex teflon vessels.
- 5 mL of internal standard, 1 mL of HF and 5 mL of HNO_3 are added.
- The vessels are sealed and heated for 12 h overnight at 120 ^{o}C on a timed hotplate, such that cooled samples are ready the following morning.
- The digests are then transferred to volumetric flasks, made up to 200 mL with distilled water and are ready for the ICP–MS.

3.5.4.2 Analysis at Geoscience Australia

ICP-MS analyses were carried out in the Onshore Energy and Minerals Division Laboratory at Geoscience Australia. The laboratory's ICP-MS is a Perkin Elmer Elan 6000, which was used to determine a range of trace elements to complement those analysed on the XRF.

The instrument was calibrated using synthetic standards. The calibrations obtained were verified against a range of USGS, SARM (South African Reference Material) and other international

standards. Australian Soil and Plant Analysis Council (ASPAC) standards were used to verify calibrations for vegetable material.

Samples were introduced to the ICP-MS as a mildly acidic aqueous solution containing approximately 100 ppm dissolved solids by way of a nebuliser that aspirates the sample with high velocity argon, forming a fine aerosol or mist. The aerosol then passed into a spray chamber where larger drops are removed via a drain. This process was necessary to produce droplets small enough to be vaporised in the plasma torch. Typically, only 2 % of the original mist passes through the spray chamber.

Trace elements routinely determined by the ICP-MS are Be, V, Cr, Ni, Cu, Zn, Ga, Ge, As, Rb, Sr, Y, Zr, Nb, Mo, Ag, Cd, Sn, Sb, Cs, Ba, La, Ce, Pr, Nd, Sm, Eu, Tb, Gd, Dy, Ho, Er, Yb, Lu, Hf, Ta, Pb, Bi, Th and U.

The analytical method used divides the analytes above into four groups. The count rate obtained for each analyte is ratioed against one of four isotopes introduced to the solution as internal standards, one for each of the analyte groups. Ni-61, Sm-147, Tm-169 and Tl-205 are the internal standard commonly used.

Inter-element interference factors are determined using a range of single element solutions. Likely inter-element interferences were selected from a Perkin Elmer compilation of theoretical interferences.

3.5.4.3 Sample preparation at Acme

The samples were sent to ACME Laboratories, Vancouver, Canada, for 'near-total' inductively coupled plasma-mass spectrometry (ICP-MS) analysis (Method 1T-MS). There, the samples were digested in a 4-acid solution as follows:

- A 0.25 g split is heated in HNO_3-$HClO_4$-HF to fuming and taken to dryness
- The residue is dissolved in HCl

3.5.4.4 Analysis at Acme

- Solutions are analysed by ICP-MS

The digestion is only partial for some Cr and Ba minerals and some oxides of Al, Hf, Mn, Sn, Ta, Zr. Volatilization during fuming may result in some loss of As, Sb and Au.

3.5.5 Inductively coupled plasma-mass spectrometry (ICP-MS) analysis of Se

Soil sub-samples (~0.2 g of <180 um and <75 um sieved samples) were digested using a strong multi-acid HF/HCl/HNO_3 digestion procedure and analysed for Se at m/z 78 using an Agilent 7500ce ICP-MS at the CSIRO Land & Water Laboratories in Adelaide. Total Se concentrations were determined in collision cell mode using the reactive gas hydrogen at a flow rate of 4 ml min^{-1}.

3.5.6 Ion selective electrode analysis of F

Fluorine concentration was determined at ALS Chemex Laboratories in Brisbane using Method F-ELE81a on the Gawler samples. The <180 um and <75 um sieved samples were fused in an alkaline flux, leached in water and made to a known volume. An aliquot of solution was treated with Total

Ionic Strength Adjustment Buffer (TISAB) and F concentrations were determined electrochemically with an ion selective electrode (ISE) using the method of standard addition.

3.5.7 Heavy minerals analysis

3.5.7.1 Sample preparation

Some Gawler sample splits were prepared for heavy mineral analysis as follows. They were weighed and emptied in plastic basins and immersed in water to disaggregate the sediments (Figure 12). Dry and naturally disaggregated (or loose) samples did not require wetting. The dry samples or wet slurries were transferred into black plastic pans for panning over a ~1 m x 1 m tub half-filled with water. The samples were repeatedly washed and panned to remove predominantly the clay and lighter fractions (equal to or lighter than quartz). The panned fraction was dried in an oven at 40 ºC overnight.

The dried panned fractions were decanted through tetrabromoethane (TBE; density 2.955) to separate heavy minerals. The separation was conducted using separation flasks (Figure 13) in a fume cupboard; acetone and ethanol were used for washing residues of TBE from the light and heavy fractions. The yield for Gawler samples varied between a few tens of grains to a few grams. Optical microscopy, magnetic separation (by hand magnet), XRD, XRF and ICP-MS were trialled for some samples. Scanning by Automatic Geological Scanning Electron Microscope or AutoGeoSEM (CSIRO, Perth) was found to be quickest method to provide a qualitative analysis of the heavy mineral fractions (density > 2.955).

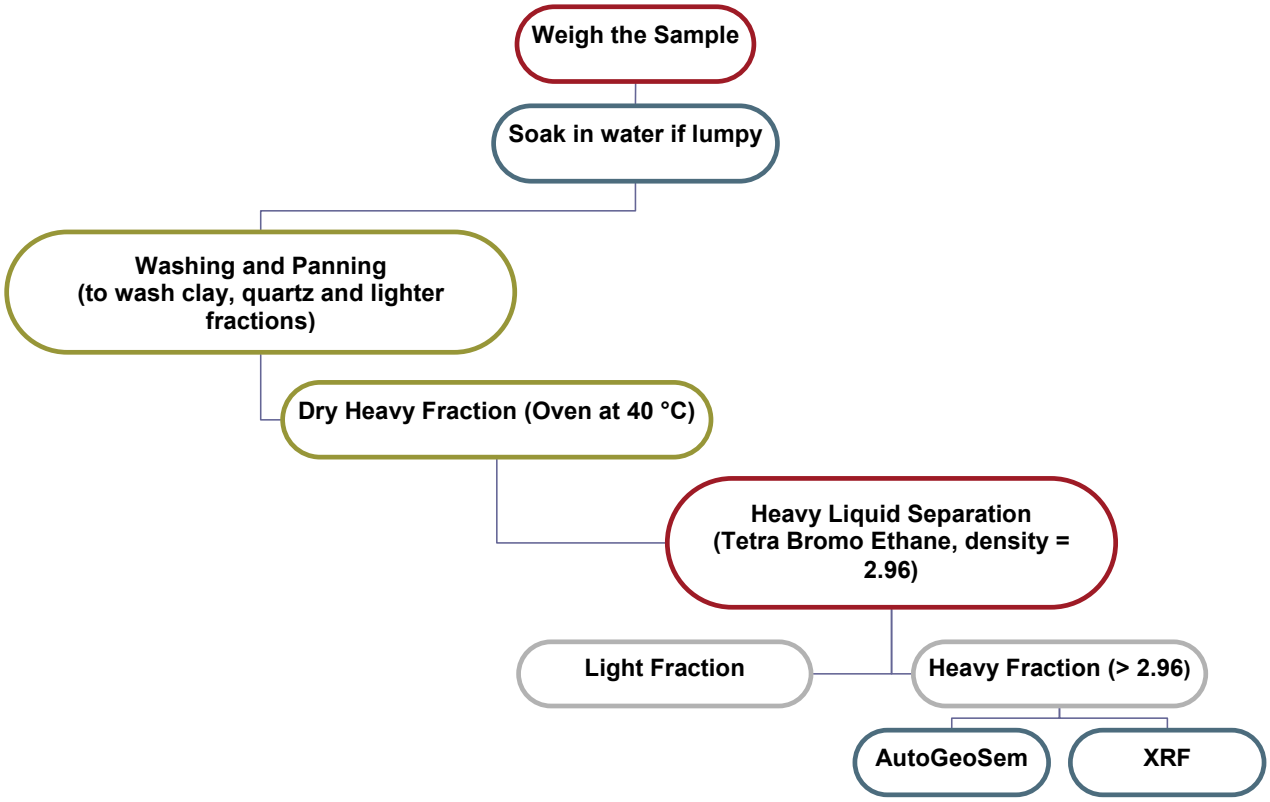


Figure 12. Flowchart showing the sample preparation process for heavy mineral separation.

Figure 13. Separation flask used for heavy mineral separation with TBE dense liquid.

3.5.7.2 Analysis

The AutoGeoSEM (Verrall, 2006) consists of a Philips XL40 Controlled Pressure SEM (Scanning Electron Microscope) fitted with an EDAX X-ray Spectrometer and custom written software for automation of the microscope and data processing. The SEM is operated in controlled pressure mode with a chamber pressure of between 0.1 to 0.7 mBar. This reduces sample charging and allows non-conductive samples to be examined without a conductive coating.

Samples to be analysed were typically mounted in resin, sectioned and polished. The polished sections were then placed in the SEM and the operator defined the area to be analysed and the parameters to be used for each sample. The AutoGeoSEM software drove the SEM stage to the first field of view, collected a back-scattered electron image and used image processing to distinguish the grains from the resin and to separate touching grains. Image analysis was then used to calculate grain attributes such as: area, width, equivalent circular diameter, perimeter, elongation, location of the centroid. Once the individual grains had been located a spectrum was collected from an included square within each grain. The spectra and images for each field of view are then stored and the process repeated for the next field of view.

For each sample, about 3000 grains were usually analysed and the total analysis time was just under an hour. The image acquisition time is usually about 5 seconds at a magnification of between x100 and x400 (depending on the grain size and detail required) and typically contain between 100 to 200 grains per field of view. The spectra acquisition time used varied from about 0.5-1 second.

The spectra collected were used to classify the grains into groups and determine the elemental composition of the grain. Each spectrum was compared to a database of standard spectra and a “Match Factor” from 0 to 100 is generated (100 indicates a perfect match). For most minerals

Match Factors of 90-95 are typical. If a measured spectrum did not match any spectra in the database then a new group is created and any similar spectra will be assigned to this group. Typically anything with a match factor of less than 85 is considered not to match and was be assigned to a new group.

3.5.8 Laser particle size analysis

All samples (bulk, dried at 40 ºC) were delivered to the Sedimentology Laboratory at Geoscience Australia to be analysed with the laser particle size analyser. The equipment used was a Malvern™ Mastersizer 2000 coupled to a Hydro 2000 MU pump unit, which allows dispersion of large volume samples using standard laboratory beakers as the sample container. The basic principles of particle size analysis are summarised by Rawle (undated), whilst Goossens (2008) compares various grain size analysis methods, including laser diffraction-based methods.

Particle size distribution was broken up into classes for sand, silt and clay according to Wentworth (1922), i.e., sand = 2 mm – 62.5 um, silt = 62.5 um – 3.9 um, clay <3.9 um.

3.5.9 pH 1:5 (soil:water) solutions

The following method was obtained from the Bureau of Rural Sciences (A. Plazinska, pers. comm., 2003).

- 30-40 g of unsieved (raw) sample was transferred into a labelled aluminium tray. Sample was placed into an oven at 45 °C for a minimum of eight hours, then placed in desiccators until samples have returned to room temperature.
- 10 g (± 0.02 g) of sample was accurately weighed into a plastic vial.
- 50 mL of distilled water was added to the vial using a Hamilton Microlab dispenser. The vial was closed and shaken by hand to ensure thorough mixing of sample.
- The sample vials were placed in plastic bowls and the bowls placed in New Brunswick shaker for one hour at 160 rpm and 25 °C.
- Samples were shaken again by hand just before being measured to ensure the sample has not settled.
- The pH was measured using a calibrated bench top pHM83 AutoCal pH metre. Meter was calibrated using pH 4 and 7 buffer solutions.
- Probes were rinsed with distilled water and dried with lab tissues between samples.

3.5.10 EC 1:5 (soil:water) solutions

The method described above was used, except EC was measured with calibrated TPS 900-C conductivity – salinity metre and temperature probe. The metre was calibrated using an appropriate standard (1409 µS/cm, 147µS/cm or 12.09 mS/cm depending on solution salinity).

3.5.11 Moisture content

Moisture content was determined for the reconnaissance field trip. Due to time constraints and low moisture content of reconnaissance samples, samples from the main field trip did not have moisture content determined.

The following method is from the Bureau of Rural Sciences (A. Plazinska, pers. comm., 2003).

- 100-120 g of unsieved (raw) sample was accurately weighed and transferred into a labelled, pre-tared aluminium tray.

- Sample was placed in a preheated oven at 105 °C for a minimum of eight hours, then place in desiccator to allow to return to room temperature.
- The weight of dry sample was accurately weighed.
- To determine moisture content:
    - Total moisture (TM) = weight of dry soil (minus tray) - weight of wet soil (minus tray),
    - Moisture content (%) = [TM/weight of dry soil (minus tray)] * 100

3.5.12 Groundwater

3.5.12.1 Sample preparation

3.5.12.1.1 Alkalinity

For the samples collected on the main field trip, field determination of total alkalinity was undertaken using a titration of 25 mL of sample water by 0.01M HCl to the methyl orange end-point. Equipment used to determine this parameter included a burette stand and clamp, 25 mL glass burette and 25 mL plastic pipette and bulb, a squeeze bottle with 0.01M HCl, methyl orange indicator, and a 100 mL glass conical flask. All glassware was well rinsed with Milli-Q® (water distilled and deionised to18.2 MΩcm resistivity using Millipore Academic A10 water purification system) water after each analysis.

- The stand and clamps were set up on a flat surface (e.g., the back of the truck).
- 25 mL of unfiltered sample water was measured with pipette and placed into the conical flask, to which 4-5 drops of methyl orange indicator was added. The water turns bright yellow.
- The burette was filled with 0.01M HCl, placed in the stand and then titrated into the conical flask until the methyl orange indicator in the solution changed to a 'sunset orange' hue immediately before turning pink.
- The amount of HCl used to the 'sunset orange' point was recorded.
- This process was repeated with a fresh water sample to obtain a second reading and if these agreed (within 10 %), their average was calculated and recorded.
- If the results varied, a third titration was performed and the average of the two most similar readings was recorded – with a note as to why one might have been different.

The average amount of HCl used was later then multiplied by the molarity (0.01) and divided by the amount of the water sample (0.025 L), giving alkalinity in mmol/L. From this, field concentrations of HCO_3^- were established by multiplying the alkalinity by molecular weight of the ion (61.0168).

3.5.12.1.2 Ferrous iron and sulfide

Concentrations of field ferrous iron (Fe^{2+}) and sulfide (S^{2-}) were determined on the main field trip using spectrophotometric methods. We used a Hach® DREL/2000 Direct Reading Spectrophotometer using the Hach® methods.

Ferrous iron concentrations were calculated using the 1,10 phenanthroline powder pillows method (method 8146) as specified in the manual (Hach, 1996).

Sulfide concentrations were calculated using the methylene blue method (method 8131) as specified in the manual (Hach, 1996).

Measurements of these unstable ions were taken within 10 minutes of sampling, to minimise the chance of alteration during transport to the camp or lab, on a non-filtered water sample.

3.5.12.1.3 Inductively coupled plasma emission spectrometry (ICP-ES) and mass spectrometry (ICP-MS)

Filtered (0.45 um) water samples (125 mL) were acidified with 1-2 mL ultra pure HNO_3 in the field. Samples were split in the lab into two 10 mL sub-samples to be submitted either to the ICP-ES lab or the ICP-MS lab. The 10 mL vials were rinsed 3 times with sample prior to filling. No further sample preparation was carried out.

3.5.12.1.4 Ion chromatography (IC)

Filtered (0.45 um) water samples (125 mL) collected in the field. The samples were kept cool and dark (fridge or cooler box with ice blocks). No further sample preparation was carried out.

3.5.12.1.5 Mass spectrometry (MS)

Samples for O and H isotopic analysis of H_2O were collected as raw water (not filtered) using Vacutainers® (product of Becton-Dickinson) in the field. No further sample preparation was carried out.

Samples for C and O isotopic analysis of HCO_3^- were collected as filtered (0.45 um) water, alkalinised (NaOH) and saturated with $BaCl_2$ (Reconnaissance trip) or $SrCl_2$ (Main trip) in the field to precipitate $BaCO_3$ or $SrCO_3$. In the laboratory, the precipitates were washed several times with Milli-Q® distilled-deionised water, filtered and dried prior to submission for analysis.

Samples for S and O isotopic analysis of SO_4^{2-} were collected as filtered (0.45 um) water, acidified (HNO_3) and saturated with $BaCl_2$ in the field to precipitate $BaSO_4$. In the laboratory, the precipitates were washed several times with Milli-Q® distilled-deionised water, filtered and dried prior to submission for analysis in Calgary.

3.5.12.1.6 Gold analysis by inductively coupled plasma mass spectrometry (ICP-MS)

Groundwater samples for Au analysis (1L) were filtered (0.45 um), salted (NaCl) and acidified (2-3 mL ultra pure HNO_3) prior to the addition of an activated carbon sachet in the field. The bottles were shaken several times in the field as well as during subsequent road transport. In the laboratory, the carbon sachets were removed from the water and air-dried.

3.5.12.2 Analysis

3.5.12.2.1 Inductively coupled plasma emission spectrometry (ICP-ES)

Major cations and some trace cations were determined by ICP-ES in the Department of Marine and Earth Sciences, the Australian National University, using a Varian Vista AX axial ICP-ES machine with a precision of ± 5 % (Dirk Kirste, pers. comm., 2005).

3.5.12.2.2 Inductively coupled plasma mass spectrometry (ICP-MS)

Minor and trace ions were determined by ICP-MS in the Ecochemistry Laboratory, Canberra University, using a Perkin Elmer ELAN 6000 equipped with a Flow Injection Analysis System (FIAS) as an online diluter and internal standard introduction system (FIAS 200 AS-90 autosampler, Perkin Elmer). Corrections were made post-analysis. Analytical precision can be up to 1 ug/L, but with samples of higher salinities, it is less reliable and should be taken at ~5 ug/L (Frank Krikowa, pers. comm., 2005; Maher *et al.*, 2003)

3.5.12.2.3 Ion chromatography (IC)

Anions were determined by IC in the Department of Marine and Earth Sciences, the Australian National University, using a Dionex® 4000i IC. An aliquot of the sample was diluted to allow bracketing by prepared standards. Precision was within the range of ±3 % (Dirk Kirste, pers. comm., 2005).

3.5.12.2.4 Ion specific electrode (ISE)

Ion specific electrodes were used to calculate F^- and I^- concentrations, undertaken at Geoscience Australia.

F^- was analysed for using an Orion Fluoride electrode model 96-09 and the Orion portable pH/ISE meter model 250Aplus. The method for analysis is outlined in TEC (2003a). The known addition method using 3 standard concentrations of 1, 10 and 100 ppm F- was used.

I^- was analysed for using an Orion Iodide Electrode 9653 and the Orion portable pH/ISE meter model 250Aplus. The method for analysis is outlined in TEC (2003b). The known addition method using 3 standard concentrations of 1, 10 and 100 ppm I^- was used.

The Orion portable pH/ISE meter was used according to TEC (2003c).

3.5.12.2.5 Mass spectrometry (MS)

Stable isotopes of O and H in H_2O were measured at the School of Geosciences, Monash University using a Finnigan MAT 252 mass spectrometer. $\delta^{18}O$ values of water were measured via equilibration with He-CO_2 at 32 °C for 24-48 hours in a Finnigan MAT Gas Bench and analysed by continuous flow. δ^2H values of water were measured via reaction with Cr at 850 °C using an automated Finnigan MAT H/Device and analysed via the dual inlet. $\delta^{18}O$ and δ^2H values were measured relative to internal standards that were calibrated using IAEA SMOW, GISP, and SLAP standards. Data were normalised following Coplen (1988) and are expressed relative to V-SMOW where $\delta^{18}O$ and δ^2H values of SLAP are –55.5 ‰ and –428 ‰, respectively. Typical precision (1σ) of the analyses based on replicate samples is $\delta^{18}O = \pm 0.15$ ‰; $\delta^2H = \pm 1$‰.

Stable isotopes of C and O in HCO_3^- were measured in the Department of Physics and Astronomy, University of Calgary, following the method described below.

<u>Overview</u>

Measurement of $\delta^{13}C$ and $\delta^{18}O$ of carbonate minerals follows the classic method in which isotopically representative CO_2 from carbonates is prepared by reaction of the sample with concentrated H_3PO_4. Parameters of H_3PO_4 preparation, reaction temperature and reaction time are carefully controlled during the phosphorolysis. Ultimately, the evolved CO_2 gas is inlet to the ion source of a stable isotope ratio mass spectrometer and analysed for the $^{13}C/^{12}C$ and $^{18}O/^{16}O$ ratios.

Gas Preparation:

- All samples delivered to the Isotope Science Laboratory, University of Calgary, must have been ground to a mesh size of at least < 60 uM.
- Approximately 10 - 20 mg of the powdered sample is weighed into one branch of a pyrex "Y" reaction tube.
- Approximately 2 - 3 ml of 103 % (density range 1.90 - 1.92 g/cm^3) H_3PO_4 is added to the other side of the "Y" reaction tube.
- The reaction tube is evacuated to ~10-3 Torr, closed and the acid and sample mixed.
- The phosphorolysis reaction is carried out at a stable room temperature of ~25 ^oC.

- After an appropriate time, the CO_2 is removed from the "Y" tube and flame sealed into a 6 mm pyrex breakseal.
- If the sample is known to be a mixture of calcite and dolomite, the CO_2 (calcite fraction) can be removed after 3-5 hours and the CO_2 (dolomite fraction) after 72 hours, from the same reaction tube, and stored in separate 6 mm breakseals for later analysis.
- The CO_2 gas from the breakseal is then inlet to the ion source of a VG 903, stable isotope ratio mass spectrometer for dual inlet analysis.

Standards

Internal Lab Standard ('Lublin' carbonate) is run at the beginning and end of each set of samples (typically 20) and are used to normalize the data as well as correct for any instrument drift. The internal lab standard is periodically calibrated against NBS 18, 19 and IAEA CO-1 International Standards. All results are reported in the permil notation relative to the international PDB standard.

The CO_2 reference gas used is typically UHP CO_2 equilibrated with Sea Water.

No fractionation corrections for dolomite are applied (see Friedman and O'Neil, 1977).

Precision and reproducibility using this technique is typically better than 0.2 permil for $\delta^{13}C$ and better than 0.3 permil for $\delta^{18}O$ (n=10 internal lab standards).

Stable isotopes of S and O in SO_4^{2-} were measured in the Department of Physics and Astronomy, University of Calgary, following the method described below.

Overview

Sulfur isotope ratios ($^{34}S/^{32}S$) of pure $BaSO_4$ and pure sulfide minerals are routinely analyzed using Continuous Flow-Isotope Ratio Mass Spectrometry (CF-EA-IRMS). The instrumentation essentially comprises a Carlo Erba NA 1500 elemental analyzer interfaced to a magnetic-sector mass analyzer. Sample materials are packed in tin cups, which are dropped by auto sampler, onto a quartz tube combustion column. The temperature of this column is maintained at 1020 ^{o}C and 'flash-combustion' is achieved by injecting a pulse of O_2(gas) exactly at the time of sample drop. The eluent gases are then swept by the He carrier stream to a VG Prism II mass spectrometer. GC separation of SO_2, CO_2 and NOx's is achieved before the gas stream is leaked through an open split into the ion source of the mass analyzer. The open split also acts as a diluter, diluting the CO_2 and NOx peaks in He prior to the SO_2 peak's elution. $\delta^{34}S$ values are determined by comparing the respective sample peak areas, as [Vs], to a reference gas peak inlet from the DI reference bellows of the mass spectrometer during each sample run.

A. Extraction

Samples must be in the form of pure $BaSO_4$ and/or pure mineral separates.

B. Gas Preparation

- Between 100 to 300 ug of pure, homogenized sample are weighed into high purity tin cups (Microanalysis; product no. D5040).
- The sample-containing cups are dropped into the high temperature (EA) combustion reactor using an A200S autosampler.
- The combustion furnace of the EA is maintained at a temperature of 1020 ^{o}C.
- Carrier flow is ~90 ml/min.
- The carrier gas (UHP He) sweeps the gaseous products through a GC column in which SO_2 is separated from NOx's and CO_2.

• Dilution of the NOx's and CO_2 peaks in He occurs before the SO_2 is introduced, via a open split/interface, to the ion source of the mass spectrometer.

Internal lab standards are analyzed repeatedly within each sample set (1 standard per ~10 samples) to guarantee quality control.

Mass Spectrometric Measurements

• Ion currents of masses 64, 65 and 66 are measured simultaneously and the 32/34 ratio of the sample gas is compared to that of a standard SO_2 reference gas (ISL ZeroBaSO4).

• Results are expressed in the usual per mil notation relative to the international V-CDT standard.

• The "raw" $\delta^{34}S$ values are normalized to V-CDT scale using the following calibrated standards:

Internal lab standards:

Standard	Supplier	$\delta^{34}S$
SeaWaterBaSO4	ISL	+20.5
FisherBaSO4	ISL	+13.7
AgS2	ISL	-2.2

International Standards

used to characterize Internal standards:

NBS 127

IAEA S-1

IAEA S-2

Internal lab standards are used at the beginning and end of each sample tray to correct for instrument drift and to normalize the data to internationally accepted standards.

Internal lab standards have been characterized against the International Standards listed above and are re-checked periodically.

PRECISION AND ACCURACY:

$\delta^{34}S$ $BaSO_4$ ±0.7 permil (n=10 internal lab standards)

3.5.12.2.6 Gold analysis by inductively coupled plasma mass spectrometry (ICP-MS)

Gold and other elements (Ag, Bi, Cu, Ni, Mo, Pd, Pt, W) were measured at Ultra Trace Laboratory in Perth, where the carbon sachets were ashed then dissolved in aqua regia prior to ICP-MS analysis. This digest is performed using plastic bottles that are discarded after use, ensuring no cross contamination. The digest is diluted, mixed and an aliquot of the acid solution is taken and analysed directly by ICP-MS or ICP-OES for Gold and other elements. As there is no organic solvent extraction, this technique will normally provide a Gold result that more closely agrees with Fire Assay.

3.6 Quality Assurance/Quality Control

Quality Assurance/Quality Control (QA/QC) was conducted in various ways to quantify bias and precision. As part of field work, regolith sample duplicates were collected to determine to what extent sample collection, preparation and analysis methods were repeatable (sampling precision). Back from the field, selected samples were split and run through the laboratories as blind duplicates to test analytical precision. Finally, samples of known composition (internal standards or Certified

Reference Materials, CRMs) were blindly submitted to the laboratories to cross check that the results returned were within target ranges (bias).

QA/QC procedures for groundwater started in the field and focused on equipment preparation both in terms of the sampling equipment and the sample containers. Jugs, bailers, flow cells, filter apparatus and other sampling equipment were rinsed 3 times with sample material before being used to collect each sample. The flow cell and filtering apparatus was rinsed 3 times with Milli-Q® water between sample locations. Sample bottles were new and rinsed 3 times with sample water before being filled. Sample bottles were also labelled with permanent marker on the side, lid, and shoulders of the bottle to ensure that labels were not lost during transport. The initial collection of 6 samples on the reconnaissance trip did not include field or travel blank samples due to timeliness. The main field trip included additional samples of a travel blank and filter blank for cation and anion analysis. Field duplicate groundwater samples from the same location at the same time were not taken.

The following section outlines the various validation methods and their results.

3.6.1 Time series

One groundwater bore was sampled twice during this project, once during the Reconnaissance trip and again during the main trip:

Yardea Home Bore: 2004851011 (sampled 3/11/2004) and 2005851201 (sampled 29/4/2005)

Changes in the chemical composition of these two samples collected about 6 months apart are given in Appendix 3.1. They can be used to assess transient changes in groundwater composition (e.g., seasonal).

For a rigorous assessment of regolith sampling precision, the reader is referred to the Thomson pilot survey (Caritat and Lech, 2007), where similar sampling methods were applied and several field duplicates collected.

3.6.2 Blind replicates

The results of sample splits inserted into the sample suites submitted for analysis without knowledge of their nature by the laboratory (blind replicates) are shown in Appendix 3.2. Also shown are "Thompson and Howarth" plots (Thompson and Howarth, 1978; Reimann *et al*., 2008). These data can be used to quantify the precision of the geochemical data.

3.6.3 Laboratory replicates

Some laboratories inserted repeat analyses of selected samples. These were done on splits of the powders provided, and put through the digestion process separately from the original sample. Results of these tests are shown in Appendix 3.3. They were used to quantify the precision of the geochemical data, bearing in mind that the lab knew of which samples these were replicates (compare with blind replicates in Appendix 3.2).

3.6.4 Laboratory standards

Some laboratories inserted a standard material in the analytical suite. Results of these tests are shown in Appendix 3.4. They are used to quantify the bias of the geochemical data.

3.6.5 Blind standards

Some reference materials where inserted in the analytical sample suite, unbeknownst to the laboratory. The purpose of inserting blind standards (unknown to the laboratory) is to quantify the bias of the geochemical data. Results of these tests are shown in Appendix 3.5.

3.6.6 Blanks

Analysis of solutions by ICP-MS can benefit from the regular insertion of blanks (distilled, deionised water) to test any carry overs in the equipment and the purity of the acid. Results of these tests are shown in Appendix 3.6.

3.7 Data analysis methods

Data generated by this project was delivered to Geoscience Australia's database group to be stored on Geoscience Australia's corporate databases DEVIANT and OZCHEM. Data analysis is performed using ESRI's ArcMap® (Minami, 2000) geographical information system (GIS) for basic spatial representation, and DAS® (Dutter *et al.*, 1995) for more advanced statistical treatment (boxplots, cumulative frequency distributions, histograms) and geochemical mapping.

Boxplots were constructed in DAS® using statistical methods from Exploratory Data Analysis (EDA) following Tukey (1977) and Velleman and Hoaglin (1981), and they are used to classify data for the production of the geochemical maps presented here (Appendix 4). The line in the middle of the box indicates the median value (50th percentile). The ends of the box or hinges represent the 1st and 3rd quartiles (25th and 75th percentiles, respectively), so that 50 % of the data is located within the box. Where the 25th and 75th percentiles coincide, the box collapses to a single line identified by a cross in the middle. The notches (square brackets) indicate how far two medians have to be from one another to be significantly different at the 5 % confidence level. The whiskers on either side of the central box extend 1.5 times the hinge spread (HS, where HS = 75th percentile – 25th percentile) away from the box. Any data point that lies outside these whiskers is considered an outlier (square symbol), and any outlier that is more than 3 x HS away from a hinge is called a far or extreme outlier (plus symbol). This method of constructing boxplots uses the inherent structure of the data to determine if outliers exist at all, and if they are extreme outliers or not. Thus, human bias of deciding that samples above the 90th, 95th or 99th percentile are 'anomalous' or not, is avoided.

For statistical analysis, results below the detection limit (DL) were replaced by ½ DL values, to enable mathematical treatment (such as ratios or log-transformation). Distributions are usually classified in 4 quartiles when a boxplot scale is not shown.

4 RESULTS AND DISCUSSION

Geochemical maps for the regolith geochemistry are shown in Appendix 4.1. Coordinates of sampling sites are given in Appendix 5.1, and the results from the various analyses performed in this project are all given in Appendices 5.2 to 5.16.

A statistical summary of the geochemical results pertaining to the regolith analyses of the TOS and BOS samples, for both grain-size fractions, is presented in Table 4.

Table 4.Summary statistics for the regolith geochemistry data from the Gawler geochemical survey. LLD = Lower Limit of Detection.

					TOS					
Parameter*	**Min**	**Med**	**Max**	**LLD**	**N**	**N >= LLD**	**% >= LLD**	**Min / LLD**	**Max / Min**	**Max - Min**
Cy_L_c_Bk	1.4	12.2	45.4		42				32.7	44.0
St_L_c_Bk	2.9	14.9	34.9		42				11.9	32.0
Sd_L_c_Bk	19.8	72.1	94.5		42				4.8	74.7
pH_F_p_Bk	6.0	8.0	9.0		42				1.5	3.0
pH15_P_p_Bk	7.7	8.7	9.6		42				1.2	1.8
EC15_E_u_Bk	6.9	53.6	2940.0		42				423.6	2933.1
Ag_M_m_75	0.06	0.12	0.31	0.01	6	6	100%	6.00	5.17	0.25
Ag_M_m_180	0.06	0.12	0.59	0.01	6	6	100%	6.00	9.83	0.53
Ag_T_m_75	<0.02	0.03	0.10	0.02	36	24	67%	Min < LLD	Min < LLD	Min < LLD
Ag_T_m_180	<0.02	<0.02	0.16	0.02	36	14	39%	Min < LLD	Min < LLD	Min < LLD
Au_A_m_75	<0.0001	0.0002	0.0036	0.0001	34	30	88%	Min < LLD	Min < LLD	Min < LLD
Au_A_m_180	<0.0001	0.0001	0.0004	0.0001	41	24	59%	Min < LLD	Min < LLD	Min < LLD
Al_X_m_75	33938.7	67628.7	128731.1	5.0	42	42	100%	6787.7	3.8	94792.3
Al_X_m_180	9993.2	34359.5	90367.4	5.0	42	42	100%	1998.6	9.0	80374.2
Al_T_m_75	33100.0	67050.0	100100.0	200.0	36	36	100%	165.5	3.0	67000.0
Al_T_m_180	10700.0	35150.0	72600.0	200.0	36	36	100%	53.5	6.8	61900.0
As_X_m_75	2.3	3.5	7.1	0.5	6	6	100%	4.6	3.1	4.8
As_X_m_180	<0.5	1.2	4.4	0.5	6	4	67%	Min < LLD	Min < LLD	Min < LLD
As_T_m_75	3.1	5.0	10.0	0.2	36	36	100%	15.5	3.2	6.9
As_T_m_180	0.6	2.4	6.6	0.2	36	36	100%	3.0	11.0	6.0
Ba_X_m_75	176	352	583	8	42	42	100%	22	3	407
Ba_X_m_180	61	248	650	8	42	42	100%	8	11	589
Ba_T_m_75	188	359	628	1	36	36	100%	188	3	440
Ba_T_m_180	66	239	660	1	36	36	100%	66	10	594
Be_M_m_75	1.4	2.1	6.0	0.1	6	6	100%	14.0	4.3	4.6
Be_M_m_180	0.7	1.5	2.6	0.1	6	6	100%	7.0	3.7	1.9
Be_T_m_75	1	2	3	1	36	36	100%	1.0	3.0	2.0
Be_T_m_180	<1	1	2	1	36	28	78%	Min < LLD	Min < LLD	Min < LLD
Bi_M_m_75	0.2	0.3	0.4	0.1	6	6	100%	2.0	2.0	0.2
Bi_M_m_180	<0.1	0.2	0.2	0.1	6	5	83%	Min < LLD	Min < LLD	Min < LLD
Bi_T_m_75	0.12	0.26	0.36	0.04	36	36	100%	3.00	3.00	0.24
Bi_T_m_180	<0.04	<0.04	0.27	0.04	36	16	44%	Min < LLD	Min < LLD	Min < LLD
Ca_X_m_75	1572	5142	166968	14	42	42	100%	112	106	165396
Ca_X_m_180	693	2902	96756	14	42	42	100%	50	140	96063
Ca_T_m_75	1700	7750	182100	200	36	36	100%	9	107	180400
Ca_T_m_180	800	3800	100500	200	36	36	100%	4	126	99700
Cd_M_m_75	<0.1	<0.1	0.1	0.1	6	2	33%	Min < LLD	Min < LLD	Min < LLD
Cd_M_m_180	<0.1	<0.1	<0.1	0.1	6	0	0%	Min < LLD	Min < LLD	Min < LLD
Cd_T_m_75	0.07	0.15	0.27	0.02	36	36	100%	3.50	3.86	0.20
Cd_T_m_180	<0.02	0.07	0.23	0.02	36	33	92%	Min < LLD	Min < LLD	Min < LLD
Ce_M_m_75	52.43	75.09	204.30	0.02	6	6	100%	2621.50	3.90	151.87
Ce_M_m_180	31.36	39.40	79.01	0.02	6	6	100%	1568.00	2.52	47.65
Ce_T_m_75	45.68	67.53	97.82	0.02	36	36	100%	2284.00	2.14	52.14
Ce_T_m_180	6.95	30.44	64.33	0.02	36	36	100%	347.50	9.26	57.38
Cl_X_m_75	<5	25	8136	5	42	27	64%	Min < LLD	Min < LLD	Min < LLD
Cl_X_m_180	<5	17	6571	5	42	27	64%	Min < LLD	Min < LLD	Min < LLD
Co_T_m_75	5.1	9.6	17.2	0.2	36	36	100%	25.5	3.4	12.1
Co_T_m_180	1.1	4.7	10.5	0.2	36	36	100%	5.5	9.5	9.4
Cr_X_m_75	<2	12	34	2	36	29	81%	Min < LLD	Min < LLD	Min < LLD
Cr_X_m_180	<2	<2	17	2	36	4	11%	Min < LLD	Min < LLD	Min < LLD
Cr_T_m_75	31	54	81	1	36	36	100%	31	3	50
Cr_T_m_180	6	26	52	1	36	36	100%	6	9	46
Cs_M_m_75	2.4	3.8	6.2	0.1	6	6	100%	24.2	2.5	3.8
Cs_M_m_180	1.1	1.8	4.0	0.1	6	6	100%	11.1	3.6	2.9
Cs_T_m_75	2.1	4.0	5.8	0.1	36	36	100%	21.0	2.8	3.7
Cs_T_m_180	0.5	2.1	3.9	0.1	36	36	100%	5.0	7.8	3.4
Cu_X_m_75	5	16	30	1	42	42	100%	5	6	25
Cu_X_m_180	<1	6	20	1	42	32	76%	Min < LLD	Min < LLD	Min < LLD
Cu_T_m_75	11.78	21.20	33.18	0.02	36	36	100%	589.00	2.82	21.40
Cu_T_m_180	3.21	11.52	24.13	0.02	36	36	100%	160.50	7.52	20.92
Dy_M_m_75	4.02	6.07	14.60	0.01	6	6	100%	402.00	3.63	10.58
Dy_M_m_180	2.02	3.10	5.11	0.01	6	6	100%	202.00	2.53	3.09
Dy_T_m_75	2.7	3.7	5.5	0.1	36	36	100%	27.0	2.0	2.8
Dy_T_m_180	0.5	1.8	5.1	0.1	36	36	100%	5.0	10.2	4.6
Er_M_m_75	2.67	4.21	8.21	0.01	6	6	100%	267.00	3.07	5.54
Er_M_m_180	1.44	2.00	2.96	0.01	6	6	100%	144.00	2.06	1.52
Er_T_m_75	1.5	2.0	3.0	0.1	36	36	100%	15.0	2.0	1.5
Er_T_m_180	0.2	1.1	2.6	0.1	36	36	100%	2.0	13.0	2.4
Eu_M_m_75	1.0710	1.2620	3.8060	0.0005	6	6	100%	2142.0000	3.5537	2.7350
Eu_M_m_180	0.5300	0.7990	1.4330	0.0005	6	6	100%	1060.0000	2.7038	0.9030
Eu_T_m_75	0.8	1.1	1.5	0.1	36	36	100%	8.0	1.9	0.7
Eu_T_m_180	0.1	0.5	1.3	0.1	36	36	100%	1.0	13.0	1.2

Table 4. Continued.

Parameter*	Min	Med	Max	LLD	N	N >= LLD	% >= LLD	Min / LLD	Max / Min	Max - Min
Ga_M_m_75	11.0	15.4	28.3	0.1	6	6	100%	110.0	2.6	17.3
Ga_M_m_180	4.6	8.3	19.6	0.1	6	6	100%	46.0	4.3	15.0
Ga_T_m_75	8.71	16.24	26.09	0.02	36	36	100%	435.50	3.00	17.38
Ga_T_m_180	2.87	8.75	17.82	0.02	36	36	100%	143.50	6.21	14.95
Gd_M_m_75	3.82	5.41	16.64	0.01	6	6	100%	382.00	4.36	12.82
Gd_M_m_180	2.08	2.96	5.78	0.01	6	6	100%	208.00	2.78	3.70
Gd_T_m_75	3.0	4.2	6.4	0.1	36	36	100%	30.0	2.1	3.4
Gd_T_m_180	0.5	2.2	5.4	0.1	36	36	100%	5.0	10.8	4.9
Ge_M_m_75	1.20	1.45	2.00	0.02	6	6	100%	60.00	1.67	0.80
Ge_M_m_180	1.00	1.35	1.50	0.02	6	6	100%	50.00	1.50	0.50
Hf_M_m_75	10.70	21.20	57.70	0.01	6	6	100%	1070.00	5.39	47.00
Hf_M_m_180	9.50	11.65	17.40	0.01	6	6	100%	950.00	1.83	7.90
Hf_T_m_75	1.42	3.37	5.83	0.02	36	36	100%	71.00	4.11	4.41
Hf_T_m_180	0.62	1.81	4.06	0.02	36	36	100%	31.00	6.55	3.44
Ho_M_m_75	0.84	1.30	2.88	0.01	6	6	100%	84.00	3.43	2.04
Ho_M_m_180	0.42	0.64	1.05	0.01	6	6	100%	42.00	2.50	0.63
Ho_T_m_75	0.5	0.7	1.1	0.1	36	36	100%	5.0	2.2	0.6
Ho_T_m_180	0.1	0.4	0.9	0.1	36	36	100%	1.0	9.0	0.8
K_X_m_75	8716	16619	24405	17	42	42	100%	513	3	15689
K_X_m_180	1320	9982	23450	17	42	42	100%	78	18	22130
K_T_m_75	8600	15200	21100	200	36	36	100%	43	2	12500
K_T_m_180	1400	9000	22400	200	36	36	100%	7	16	21000
La_M_m_75	26.10	37.60	90.16	0.02	6	6	100%	1305.00	3.45	64.06
La_M_m_180	16.36	20.11	34.57	0.02	6	6	100%	818.00	2.11	18.21
La_T_m_75	19.8	29.7	42.3	0.1	36	36	100%	198.0	2.1	22.5
La_T_m_180	3.0	14.6	31.7	0.1	36	36	100%	30.0	10.6	28.7
Li_T_m_75	18.0	33.0	51.3	0.1	36	36	100%	180.0	2.9	33.3
Li_T_m_180	6.5	19.4	36.4	0.1	36	36	100%	65.0	5.6	29.9
Lu_M_m_75	0.44	0.73	1.02	0.01	6	6	100%	44.00	2.32	0.58
Lu_M_m_180	0.23	0.32	0.41	0.01	6	6	100%	23.00	1.78	0.18
Lu_T_m_75	0.2	0.3	0.5	0.1	36	36	100%	2.0	2.5	0.3
Lu_T_m_180	<0.1	0.2	0.4	0.1	36	35	97%	Min < LLD	Min < LLD	Min < LLD
Mg_X_m_75	2141	6732	20743	24	42	42	100%	89	10	18603
Mg_X_m_180	422	2931	13254	24	42	42	100%	18	31	12832
Mg_T_m_75	2100	6550	18700	200	36	36	100%	11	9	16600
Mg_T_m_180	600	2900	12600	200	36	36	100%	3	21	12000
LOIc_Z_m_75	50144	122990	320998	10	42	42	100%	5014	6	270854
LOIc_Z_m_180	11984	62149	195836	10	42	42	100%	1198	16	183852
Mn_X_m_75	225	472	736	8	42	42	100%	28	3	511
Mn_X_m_180	54	232	480	8	42	42	100%	7	9	426
Mn_T_m_75	223	492	719	2	36	36	100%	112	3	496
Mn_T_m_180	48	247	517	2	36	36	100%	24	11	469
Mo_M_m_75	0.3	1.0	1.3	0.1	6	6	100%	3.0	4.3	1.0
Mo_M_m_180	<0.1	0.9	1.4	0.1	6	5	83%	Min < LLD	Min < LLD	Min < LLD
Mo_T_m_75	0.45	0.69	2.03	0.05	36	36	100%	9.00	4.51	1.58
Mo_T_m_180	0.17	0.38	1.16	0.05	36	36	100%	3.40	6.82	0.99
Na_X_m_75	1194	1973	7434	30	42	42	100%	40	6	6239
Na_X_m_180	134	1094	6477	30	42	42	100%	4	49	6343
Na_T_m_75	1050	2000	6930	20	36	36	100%	53	7	5880
Na_T_m_180	170	1060	6610	20	36	36	100%	9	39	6440
Nb_M_m_75	10.70	16.85	22.80	0.04	6	6	100%	267.50	2.13	12.10
Nb_M_m_180	4.30	9.65	11.50	0.04	6	6	100%	107.50	2.67	7.20
Nb_T_m_75	4.85	10.12	13.33	0.04	36	36	100%	121.25	2.75	8.48
Nb_T_m_180	1.97	5.54	10.62	0.04	36	36	100%	49.25	5.39	8.65
Nd_M_m_75	23.75	32.93	93.71	0.01	6	6	100%	2375.00	3.95	69.96
Nd_M_m_180	14.95	17.69	34.39	0.01	6	6	100%	1495.00	2.30	19.44
Nd_T_m_75	18.7	28.9	37.7	0.1	36	36	100%	187.0	2.0	19.0
Nd_T_m_180	2.9	13.5	31.7	0.1	36	36	100%	29.0	10.9	28.8
Ni_X_m_75	7	18	38	2	42	42	100%	4	5	31
Ni_X_m_180	<2	10	23	2	42	36	86%	Min < LLD	Min < LLD	Min < LLD
Ni_T_m_75	10.6	20.6	33.6	0.1	36	36	100%	106.0	3.2	23.0
Ni_T_m_180	2.4	11.3	21.9	0.1	36	36	100%	24.0	9.1	19.5
P_X_m_75	192	401	1004	4	42	42	100%	48	5	812
P_X_m_180	65	225	659	4	42	42	100%	16	10	594
P_T_m_75	160	430	1120	10	36	36	100%	16	7	960
P_T_m_180	40	240	720	10	36	36	100%	4	18	680
Pb_M_m_75	17.9	20.5	22.7	0.5	6	6	100%	35.8	1.3	4.8
Pb_M_m_180	7.8	12.0	15.9	0.5	6	6	100%	15.6	2.0	8.1
Pb_T_m_75	11.78	20.01	25.55	0.02	36	36	100%	589.00	2.17	13.77
Pb_T_m_180	3.33	11.58	21.98	0.02	36	36	100%	166.50	6.60	18.65
Pr_M_m_75	6.65	9.31	25.57	0.01	6	6	100%	665.00	3.85	18.92
Pr_M_m_180	4.23	5.06	9.41	0.01	6	6	100%	423.00	2.22	5.18
Pr_T_m_75	4.4	6.9	9.1	0.1	36	36	100%	44.0	2.1	4.7
Pr_T_m_180	0.7	3.3	7.4	0.1	36	36	100%	7.0	10.6	6.7

Table 4. Continued.

Parameter*	Min	Med	Max	LLD	N	N >= LLD	% >= LLD	Min / LLD	Max / Min	Max - Min
Sb_M_m_180	0.40	0.80	3.30	0.01	6	6	100%	40.00	8.25	2.90
Sb_T_m_75	0.26	0.38	0.69	0.02	36	36	100%	13.00	2.65	0.43
Sb_T_m_180	<0.02	0.22	0.91	0.02	36	35	97%	Min < LLD	Min < LLD	Min < LLD
Sc_X_m_75	<2	6	21	2	42	37	88%	Min < LLD	Min < LLD	Min < LLD
Sc_X_m_180	<2	2	17	2	42	23	55%	Min < LLD	Min < LLD	Min < LLD
Sc_T_m_75	5.7	12.0	17.7	0.1	36	36	100%	57.0	3.1	12.0
Sc_T_m_180	1.6	5.5	11.5	0.1	36	36	100%	16.0	7.2	9.9
Se_C_m_75	0.16	0.30	1.01	0.04	29	29	100%	3.98	6.36	0.85
Se_C_m_180	0.06	0.14	0.39	0.04	36	36	100%	1.49	6.57	0.33
Si_X_m_75	142090	283990	371260	28	42	42	100%	5075	3	229171
Si_X_m_180	245282	374495	442646	28	42	42	100%	8760	2	197364
Sm_M_m_75	4.95	7.08	18.67	0.01	6	6	100%	495.00	3.77	13.72
Sm_M_m_180	2.80	3.90	6.76	0.01	6	6	100%	280.00	2.41	3.96
Sm_T_m_75	3.9	5.4	7.6	0.1	36	36	100%	39.0	1.9	3.7
Sm_T_m_180	0.5	2.7	6.8	0.1	36	36	100%	5.0	13.6	6.3
Sn_M_m_75	2.2	2.9	3.8	0.5	6	6	100%	4.4	1.7	1.6
Sn_M_m_180	0.9	2.0	3.6	0.5	6	6	100%	1.8	4.0	2.7
Sn_T_m_75	1.2	2.4	3.2	0.1	36	36	100%	12.0	2.7	2.0
Sn_T_m_180	0.4	1.3	4.7	0.1	36	36	100%	4.0	11.8	4.3
S_X_m_75	100	172	3348	4	42	42	100%	25	33	3248
S_X_m_180	48	116	1830	4	42	42	100%	12	38	1782
S_T_m_75	<400	<400	8500	400	36	13	36%	Min < LLD	Min < LLD	Min < LLD
S_T_m_180	<400	<400	4700	400	36	4	11%	Min < LLD	Min < LLD	Min < LLD
Sr_X_m_75	60	109	770	1	42	42	100%	60	13	710
Sr_X_m_180	10	58	441	1	42	42	100%	10	44	431
Sr_T_m_75	65	122	772	1	36	36	100%	65	12	707
Sr_T_m_180	16	66	454	1	36	36	100%	16	28	438
Ta_M_m_75	0.7	1.0	1.3	0.1	6	6	100%	7.0	1.9	0.6
Ta_M_m_180	0.1	0.5	0.6	0.1	6	6	100%	1.0	6.0	0.5
Ta_T_m_75	0.5	1.1	1.5	0.1	36	36	100%	5.0	3.0	1.0
Ta_T_m_180	0.2	0.6	1.0	0.1	36	36	100%	2.0	5.0	0.8
Tb_M_m_75	0.68	0.93	2.58	0.01	6	6	100%	68.00	3.79	1.90
Tb_M_m_180	0.32	0.48	0.90	0.01	6	6	100%	32.00	2.81	0.58
Tb_T_m_75	0.5	0.7	0.9	0.1	36	36	100%	5.0	1.8	0.4
Tb_T_m_180	0.1	0.3	0.7	0.1	36	36	100%	1.0	7.0	0.6
Th_M_m_75	10.50	19.20	26.20	0.01	6	6	100%	1050.00	2.50	15.70
Th_M_m_180	4.40	9.75	16.20	0.01	6	6	100%	440.00	3.68	11.80
Th_T_m_75	6.3	13.3	39.0	0.1	36	36	100%	63.0	6.2	32.7
Th_T_m_180	2.1	6.3	12.3	0.1	36	36	100%	21.0	5.9	10.2
Ti_X_m_75	2469	5562	8001	12	42	42	100%	206	3	5532
Ti_X_m_180	851	2829	4645	12	42	42	100%	71	5	3794
Ti_T_m_75	2290	4950	6360	10	36	36	100%	229	3	4070
Ti_T_m_180	750	2720	4190	10	36	36	100%	75	6	3440
Tm_T_m_75	0.2	0.3	0.5	0.1	36	36	100%	2.0	2.5	0.3
Tm_T_m_180	<0.1	0.2	0.4	0.1	36	34	94%	Min < LLD	Min < LLD	Min < LLD
U_M_m_75	1.85	2.84	4.49	0.07	6	6	100%	26.43	2.43	2.64
U_M_m_180	0.73	1.35	1.88	0.07	6	6	100%	10.43	2.58	1.15
U_T_m_75	0.7	1.3	4.1	0.1	36	36	100%	7.0	5.9	3.4
U_T_m_180	0.2	0.7	2.2	0.1	36	36	100%	2.0	11.0	2.0
V_X_m_75	26	66	116	2	36	36	100%	13	4	90
V_X_m_180	<2	35	84	2	36	34	94%	Min < LLD	Min < LLD	Min < LLD
V_T_m_75	39	78	148	1	36	36	100%	39	4	109
V_T_m_180	10	45	101	1	36	36	100%	10	10	91
W_T_m_75	0.5	1.0	1.7	0.1	36	36	100%	5.0	3.4	1.2
W_T_m_180	0.2	0.6	1.1	0.1	36	36	100%	2.0	5.5	0.9
Y_M_m_75	23.90	43.70	66.60	0.01	6	6	100%	2390.00	2.79	42.70
Y_M_m_180	14.80	21.75	32.20	0.01	6	6	100%	1480.00	2.18	17.40
Y_T_m_75	14.6	19.6	28.2	0.1	36	36	100%	146.0	1.9	13.6
Y_T_m_180	2.5	10.0	25.2	0.1	36	36	100%	25.0	10.1	22.7
Yb_M_m_75	2.82	4.59	6.67	0.01	6	6	100%	282.00	2.37	3.85
Yb_M_m_180	1.55	2.11	2.58	0.01	6	6	100%	155.00	1.66	1.03
Yb_T_m_75	1.5	2.1	3.2	0.1	36	36	100%	15.0	2.1	1.7
Yb_T_m_180	0.2	1.0	2.3	0.1	36	36	100%	2.0	11.5	2.1
Zn_X_m_75	14	54	92	1	42	42	100%	14	7	78
Zn_X_m_180	<1	25	63	1	42	40	95%	Min < LLD	Min < LLD	Min < LLD
Zn_T_m_75	29.5	69.4	106.2	0.2	36	36	100%	147.5	3.6	76.7
Zn_T_m_180	7.4	41.3	77.9	0.2	36	36	100%	37.0	10.5	70.5
Zr_X_m_75	259	837	1842	1	42	42	100%	259	7	1583
Zr_X_m_180	212	395	606	1	42	42	100%	212	3	394
Zr_T_m_75	48.5	104.4	182.3	0.2	36	36	100%	242.5	3.8	133.8
Zr_T_m_180	20.8	55.8	127.1	0.2	36	36	100%	104.0	6.1	106.3

Table 4. Continued.

					BOS					
Parameter*	Min	Med	Max	LLD	N	N >= LLD	% >= LLD	Min / LLD	Max / Min	Max - Min
Cy_L_c_Bk	3.0	16.3	53.2		42				17.9	50.2
St_L_c_Bk	4.0	19.3	36.5		42				9.0	32.5
Sd_L_c_Bk	20.5	59.2	92.7		42				4.5	72.2
pH_F_p_Bk	5.0	8.5	9.5		42				1.9	4.5
pH15_P_p_Bk	7.6	9.0	9.8		42				1.3	2.2
EC15_E_u_Bk	10.4	550.0	6710.0		42				645.8	6699.6
Ag_M_m_75	0.06	0.13	0.18	0.01	6	6	100%	6.00	3.00	0.12
Ag_M_m_180	0.06	0.15	0.32	0.01	6	6	100%	6.00	5.33	0.26
Ag_T_m_75	<0.02	0.04	0.10	0.02	36	32	89%	Min < LLD	Min < LLD	Min < LLD
Ag_T_m_180	<0.02	0.03	0.27	0.02	36	28	78%	Min < LLD	Min < LLD	Min < LLD
Au_A_m_75	0.0001	0.0010	0.0050	0.0001	33	33	100%	1.0000	50.0000	0.0049
Au_A_m_180	<0.0001	0.0005	0.0134	0.0001	41	36	88%	Min < LLD	Min < LLD	Min < LLD
Al_X_m_75	11385.2	48063.1	141439.5	5.0	42	42	100%	2277.0	12.4	130054.3
Al_X_m_180	7823.1	33454.4	128535.2	5.0	42	42	100%	1564.6	16.4	120712.2
Al_T_m_75	11600.0	50700.0	112600.0	200.0	36	36	100%	58.0	9.7	101000.0
Al_T_m_180	9500.0	36150.0	89700.0	200.0	36	36	100%	47.5	9.4	80200.0
As_X_m_75	<0.5	5.0	9.1	0.5	6	5	83%	Min < LLD	Min < LLD	Min < LLD
As_X_m_180	<0.5	4.0	8.3	0.5	6	5	83%	Min < LLD	Min < LLD	Min < LLD
As_T_m_75	2.1	5.9	11.1	0.2	36	36	100%	10.5	5.3	9.0
As_T_m_180	0.3	3.7	8.7	0.2	36	36	100%	1.5	29.0	8.4
Ba_X_m_75	56	295	1632	8	42	42	100%	7	29	1576
Ba_X_m_180	63	225	1141	8	42	42	100%	8	18	1078
Ba_T_m_75	34	287	832	1	36	36	100%	34	24	798
Ba_T_m_180	44	211	605	1	36	36	100%	44	14	561
Be_M_m_75	0.4	1.7	4.5	0.1	6	6	100%	4.0	11.3	4.1
Be_M_m_180	0.7	1.5	1.8	0.1	6	6	100%	7.0	2.6	1.1
Be_T_m_75	<1	1	3	1	36	34	94%	Min < LLD	Min < LLD	Min < LLD
Be_T_m_180	<1	1	2	1	36	27	75%	Min < LLD	Min < LLD	Min < LLD
Bi_M_m_75	<0.1	0.2	0.3	0.1	6	5	83%	Min < LLD	Min < LLD	Min < LLD
Bi_M_m_180	<0.1	<0.1	0.3	0.1	6	3	50%	Min < LLD	Min < LLD	Min < LLD
Bi_T_m_75	<0.04	0.18	0.32	0.04	36	35	97%	Min < LLD	Min < LLD	Min < LLD
Bi_T_m_180	0.04	0.14	0.30	0.04	36	36	100%	1.00	7.50	0.26
Ca_X_m_75	1344	101905	316362	14	42	42	100%	96	235	315018
Ca_X_m_180	686	37390	194677	14	42	42	100%	49	284	193991
Ca_T_m_75	1600	87650	314300	200	36	36	100%	8	196	312700
Ca_T_m_180	800	33000	199000	200	36	36	100%	4	249	198200
Cd_M_m_75	<0.1	<0.1	<0.1	0.1	6	0	0%	Min < LLD	Min < LLD	Min < LLD
Cd_M_m_180	<0.1	<0.1	<0.1	0.1	6	0	0%	Min < LLD	Min < LLD	Min < LLD
Cd_T_m_75	0.02	0.11	0.23	0.02	36	36	100%	1.00	11.50	0.21
Cd_T_m_180	<0.02	0.06	0.12	0.02	36	30	83%	Min < LLD	Min < LLD	Min < LLD
Ce_M_m_75	18.02	42.78	170.10	0.02	6	6	100%	901.00	9.44	152.08
Ce_M_m_180	15.03	35.11	55.23	0.02	6	6	100%	751.50	3.67	40.20
Ce_T_m_75	14.64	48.42	104.51	0.02	36	36	100%	732.00	7.14	89.87
Ce_T_m_180	8.83	27.92	60.91	0.02	36	36	100%	441.50	6.90	52.08
Cl_X_m_75	<5	2094	11734	5	42	31	74%	Min < LLD	Min < LLD	Min < LLD
Cl_X_m_180	<5	988	11598	5	42	30	71%	Min < LLD	Min < LLD	Min < LLD
Co_T_m_75	2.7	8.9	13.2	0.2	36	36	100%	13.5	4.9	10.5
Co_T_m_180	1.1	5.3	12.3	0.2	36	36	100%	5.5	11.2	11.2
Cr_X_m_75	<2	<2	34	2	36	15	42%	Min < LLD	Min < LLD	Min < LLD
Cr_X_m_180	<2	<2	20	2	36	3	8%	Min < LLD	Min < LLD	Min < LLD
Cr_T_m_75	12	40	74	1	36	36	100%	12	6	62
Cr_T_m_180	6	28	57	1	36	36	100%	6	10	51
Cs_M_m_75	0.7	2.7	6.0	0.1	6	6	100%	7.0	8.6	5.3
Cs_M_m_180	0.7	1.5	5.1	0.1	6	6	100%	6.5	7.9	4.5
Cs_T_m_75	0.8	3.3	7.0	0.1	36	36	100%	8.0	8.8	6.2
Cs_T_m_180	0.5	2.3	5.2	0.1	36	36	100%	5.0	10.4	4.7
Cu_X_m_75	<1	17	32	1	42	40	95%	Min < LLD	Min < LLD	Min < LLD
Cu_X_m_180	<1	9	25	1	42	37	88%	Min < LLD	Min < LLD	Min < LLD
Cu_T_m_75	6.06	21.21	36.77	0.02	36	36	100%	303.00	6.07	30.71
Cu_T_m_180	4.07	15.64	26.75	0.02	36	36	100%	203.50	6.57	22.68
Dy_M_m_75	1.42	3.18	13.17	0.01	6	6	100%	142.00	9.27	11.75
Dy_M_m_180	1.04	2.57	4.59	0.01	6	6	100%	104.00	4.41	3.55
Dy_T_m_75	1.1	3.3	5.9	0.1	36	36	100%	11.0	5.4	4.8
Dy_T_m_180	0.4	1.9	3.9	0.1	36	36	100%	4.0	9.8	3.5
Er_M_m_75	1.07	2.05	7.77	0.01	6	6	100%	107.00	7.26	6.70
Er_M_m_180	0.75	1.68	2.81	0.01	6	6	100%	75.00	3.75	2.06
Er_T_m_75	0.6	1.7	3.2	0.1	36	36	100%	6.0	5.3	2.6
Er_T_m_180	0.3	1.1	2.2	0.1	36	36	100%	3.0	7.3	1.9
Eu_M_m_75	0.3350	0.7660	3.3960	0.0005	6	6	100%	670.0000	10.1373	3.0610
Eu_M_m_180	0.2670	0.5955	1.0660	0.0005	6	6	100%	534.0000	3.9925	0.7990
Eu_T_m_75	0.3	0.9	1.8	0.1	36	36	100%	3.0	6.0	1.5
Eu_T_m_180	0.1	0.5	1.2	0.1	36	36	100%	1.0	12.0	1.1

Table 4. Continued.

Parameter*	Min	Med	Max	LLD	N	N >= LLD	% >= LLD	Min / LLD	Max / Min	Max - Min
Ga_M_m_75	2.8	11.0	32.2	0.1	6	6	100%	28.0	11.5	29.4
Ga_M_m_180	2.7	6.9	29.2	0.1	6	6	100%	27.0	10.8	26.5
Ga_T_m_75	3.01	12.42	29.96	0.02	36	36	100%	150.50	9.95	26.95
Ga_T_m_180	2.18	8.88	23.37	0.02	36	36	100%	109.00	10.72	21.19
Gd_M_m_75	1.36	3.02	15.15	0.01	6	6	100%	136.00	11.14	13.79
Gd_M_m_180	1.03	2.40	4.68	0.01	6	6	100%	103.00	4.54	3.65
Gd_T_m_75	1.2	3.5	7.5	0.1	36	36	100%	12.0	6.3	6.3
Gd_T_m_180	0.6	2.2	4.3	0.1	36	36	100%	6.0	7.2	3.7
Ge_M_m_75	0.50	0.95	2.00	0.02	6	6	100%	25.00	4.00	1.50
Ge_M_m_180	0.60	0.85	1.90	0.02	6	6	100%	30.00	3.17	1.30
Hf_M_m_75	5.10	9.35	22.80	0.01	6	6	100%	510.00	4.47	17.70
Hf_M_m_180	5.70	7.80	13.50	0.01	6	6	100%	570.00	2.37	7.80
Hf_T_m_75	0.56	2.79	5.02	0.02	36	36	100%	28.00	8.96	4.46
Hf_T_m_180	0.39	1.79	3.46	0.02	36	36	100%	19.50	8.87	3.07
Ho_M_m_75	0.32	0.62	2.68	0.01	6	6	100%	32.00	8.38	2.36
Ho_M_m_180	0.22	0.53	0.92	0.01	6	6	100%	22.00	4.18	0.70
Ho_T_m_75	0.2	0.6	1.2	0.1	36	36	100%	2.0	6.0	1.0
Ho_T_m_180	0.1	0.4	0.8	0.1	36	36	100%	1.0	8.0	0.7
K_X_m_75	2889	10194	26588	17	42	42	100%	170	9	23699
K_X_m_180	1494	7330	16320	17	42	42	100%	88	11	14826
K_T_m_75	2700	10650	25800	200	36	36	100%	14	10	23100
K_T_m_180	1500	7500	17200	200	36	36	100%	8	11	15700
La_M_m_75	11.80	19.60	80.80	0.02	6	6	100%	590.00	6.85	69.00
La_M_m_180	8.87	16.59	25.71	0.02	6	6	100%	443.50	2.90	16.84
La_T_m_75	6.6	23.1	69.0	0.1	36	36	100%	66.0	10.5	62.4
La_T_m_180	3.9	13.4	38.0	0.1	36	36	100%	39.0	9.7	34.1
Li_T_m_75	7.4	27.3	61.9	0.1	36	36	100%	74.0	8.4	54.5
Li_T_m_180	5.8	19.3	48.7	0.1	36	36	100%	58.0	8.4	42.9
Lu_M_m_75	0.18	0.33	1.05	0.01	6	6	100%	18.00	5.83	0.87
Lu_M_m_180	0.11	0.27	0.40	0.01	6	6	100%	11.00	3.64	0.29
Lu_T_m_75	0.1	0.3	0.5	0.1	36	36	100%	1.0	5.0	0.4
Lu_T_m_180	<0.1	0.1	0.3	0.1	36	32	89%	Min < LLD	Min < LLD	Min < LLD
Mg_X_m_75	1845	9506	29921	24	42	42	100%	77	16	28076
Mg_X_m_180	657	5312	18627	24	42	42	100%	27	28	17969
Mg_T_m_75	1900	9000	27800	200	36	36	100%	10	15	25900
Mg_T_m_180	800	5300	18100	200	36	36	100%	4	23	17300
LOIc_Z_m_75	50156	244159	415854	10	42	42	100%	5016	8	365698
LOIc_Z_m_180	18734	140337	294656	10	42	42	100%	1873	16	275922
Mn_X_m_75	54	221	534	8	42	42	100%	7	10	480
Mn_X_m_180	46	139	441	8	42	42	100%	6	10	395
Mn_T_m_75	48	234	522	2	36	36	100%	24	11	474
Mn_T_m_180	35	140	628	2	36	36	100%	18	18	593
Mo_M_m_75	0.5	0.8	0.8	0.1	6	6	100%	5.0	1.6	0.3
Mo_M_m_180	<0.1	1.1	1.6	0.1	6	5	83%	Min < LLD	Min < LLD	Min < LLD
Mo_T_m_75	0.16	0.57	1.38	0.05	36	36	100%	3.20	8.63	1.22
Mo_T_m_180	0.14	0.42	1.01	0.05	36	36	100%	2.80	7.21	0.87
Na_X_m_75	734	3339	12034	30	42	42	100%	24	16	11299
Na_X_m_180	185	2292	11269	30	42	42	100%	6	61	11084
Na_T_m_75	680	3015	12160	20	36	36	100%	34	18	11480
Na_T_m_180	190	2165	11060	20	36	36	100%	10	58	10870
Nb_M_m_75	4.10	8.75	14.40	0.04	6	6	100%	102.50	3.51	10.30
Nb_M_m_180	3.80	5.95	13.40	0.04	6	6	100%	95.00	3.53	9.60
Nb_T_m_75	2.05	8.19	12.48	0.04	36	36	100%	51.25	6.09	10.43
Nb_T_m_180	1.30	5.01	8.64	0.04	36	36	100%	32.50	6.65	7.34
Nd_M_m_75	8.35	17.29	83.76	0.01	6	6	100%	835.00	10.03	75.41
Nd_M_m_180	6.80	15.38	25.71	0.01	6	6	100%	680.00	3.78	18.91
Nd_T_m_75	6.4	23.3	42.9	0.1	36	36	100%	64.0	6.7	36.5
Nd_T_m_180	3.5	12.4	28.4	0.1	36	36	100%	35.0	8.1	24.9
Ni_X_m_75	<2	14	37	2	42	39	93%	Min < LLD	Min < LLD	Min < LLD
Ni_X_m_180	<2	9	40	2	42	34	81%	Min < LLD	Min < LLD	Min < LLD
Ni_T_m_75	4.9	18.3	32.1	0.1	36	36	100%	49.0	6.6	27.2
Ni_T_m_180	2.7	12.6	26.2	0.1	36	36	100%	27.0	9.7	23.5
P_X_m_75	70	236	1012	4	42	42	100%	17	15	943
P_X_m_180	65	166	672	4	42	42	100%	16	10	607
P_T_m_75	100	255	1110	10	36	36	100%	10	11	1010
P_T_m_180	50	175	740	10	36	36	100%	5	15	690
Pb_M_m_75	5.4	13.0	14.8	0.5	6	6	100%	10.8	2.7	9.4
Pb_M_m_180	4.6	8.1	13.0	0.5	6	6	100%	9.2	2.8	8.4
Pb_T_m_75	3.08	14.57	34.50	0.02	36	36	100%	154.00	11.20	31.42
Pb_T_m_180	2.47	10.40	19.08	0.02	36	36	100%	123.50	7.72	16.61
Pr_M_m_75	2.32	4.83	22.70	0.01	6	6	100%	232.00	9.78	20.38
Pr_M_m_180	1.96	4.25	7.05	0.01	6	6	100%	196.00	3.60	5.09
Pr_T_m_75	2.0	5.5	10.5	0.1	36	36	100%	20.0	5.3	8.5
Pr_T_m_180	1.0	3.5	7.1	0.1	36	36	100%	10.0	7.1	6.1

Table 4. Continued.

Parameter*	Min	Med	Max	LLD	N	N >= LLD	% >= LLD	Min / LLD	Max / Min	Max - Min
Sb_M_m_180	0.50	1.05	4.70	0.01	6	6	100%	50.00	9.40	4.20
Sb_T_m_75	0.12	0.32	0.49	0.02	36	36	100%	6.00	4.08	0.37
Sb_T_m_180	<0.02	0.12	0.42	0.02	36	30	83%	Min < LLD	Min < LLD	Min < LLD
Sc_X_m_75	<2	<2	22	2	42	21	50%	Min < LLD	Min < LLD	Min < LLD
Sc_X_m_180	<2	<2	19	2	42	15	36%	Min < LLD	Min < LLD	Min < LLD
Sc_T_m_75	2.4	8.4	20.2	0.1	36	36	100%	24.0	8.4	17.8
Sc_T_m_180	1.2	5.7	15.2	0.1	36	36	100%	12.0	12.7	14.0
Se_C_m_75	0.11	0.41	1.73	0.04	27	27	100%	2.66	16.24	1.62
Se_C_m_180	0.06	0.25	1.02	0.04	36	36	100%	1.45	17.64	0.97
Si_X_m_75	48353	192611	372008	28	42	42	100%	1727	8	323656
Si_X_m_180	147381	291361	438150	28	42	42	100%	5264	3	290770
Sm_M_m_75	1.54	3.79	17.22	0.01	6	6	100%	154.00	11.18	15.68
Sm_M_m_180	1.41	3.22	5.24	0.01	6	6	100%	141.00	3.72	3.83
Sm_T_m_75	1.3	4.4	8.2	0.1	36	36	100%	13.0	6.3	6.9
Sm_T_m_180	0.8	2.4	5.5	0.1	36	36	100%	8.0	6.9	4.7
Sn_M_m_75	0.7	1.7	3.5	0.5	6	6	100%	1.4	5.0	2.8
Sn_M_m_180	<0.5	1.0	3.1	0.5	6	5	83%	Min < LLD	Min < LLD	Min < LLD
Sn_T_m_75	0.4	1.7	4.3	0.1	36	36	100%	4.0	10.8	3.9
Sn_T_m_180	<0.1	1.3	3.0	0.1	36	35	97%	Min < LLD	Min < LLD	Min < LLD
S_X_m_75	64	260	109096	4	42	42	100%	16	1703	109032
S_X_m_180	36	176	77725	4	42	42	100%	9	2156	77689
S_T_m_75	<400	600	96400	400	36	28	78%	Min < LLD	Min < LLD	Min < LLD
S_T_m_180	<400	<400	62300	400	36	14	39%	Min < LLD	Min < LLD	Min < LLD
Sr_X_m_75	57	299	5420	1	42	42	100%	57	95	5363
Sr_X_m_180	13	149	2605	1	42	42	100%	13	200	2592
Sr_T_m_75	66	314	5537	1	36	36	100%	66	84	5471
Sr_T_m_180	18	157	2910	1	36	36	100%	18	162	2892
Ta_M_m_75	<0.1	0.4	0.9	0.1	6	5	83%	Min < LLD	Min < LLD	Min < LLD
Ta_M_m_180	<0.1	0.3	0.8	0.1	6	5	83%	Min < LLD	Min < LLD	Min < LLD
Ta_T_m_75	0.2	0.8	1.3	0.1	36	36	100%	2.0	6.5	1.1
Ta_T_m_180	0.1	0.5	0.9	0.1	36	36	100%	1.0	9.0	0.8
Tb_M_m_75	0.22	0.52	2.34	0.01	6	6	100%	22.00	10.64	2.12
Tb_M_m_180	0.18	0.41	0.73	0.01	6	6	100%	18.00	4.06	0.55
Tb_T_m_75	0.2	0.5	1.0	0.1	36	36	100%	2.0	5.0	0.8
Tb_T_m_180	0.1	0.3	0.6	0.1	36	36	100%	1.0	6.0	0.5
Th_M_m_75	4.00	9.65	21.60	0.01	6	6	100%	400.00	5.40	17.60
Th_M_m_180	4.10	6.20	20.70	0.01	6	6	100%	410.00	5.05	16.60
Th_T_m_75	2.4	9.7	65.1	0.1	36	36	100%	24.0	27.1	62.7
Th_T_m_180	1.7	5.9	18.7	0.1	36	36	100%	17.0	11.0	17.0
Ti_X_m_75	1031	3761	6257	12	42	42	100%	86	6	5226
Ti_X_m_180	845	2445	5250	12	42	42	100%	70	6	4405
Ti_T_m_75	820	3840	5660	10	36	36	100%	82	7	4840
Ti_T_m_180	720	2585	4730	10	36	36	100%	72	7	4010
Tm_T_m_75	0.1	0.3	0.5	0.1	36	36	100%	1.0	5.0	0.4
Tm_T_m_180	<0.1	0.2	0.3	0.1	36	31	86%	Min < LLD	Min < LLD	Min < LLD
U_M_m_75	1.16	1.63	2.45	0.07	6	6	100%	16.57	2.11	1.29
U_M_m_180	0.79	1.07	2.30	0.07	6	6	100%	11.29	2.91	1.51
U_T_m_75	0.6	1.3	11.8	0.1	36	36	100%	6.0	19.7	11.2
U_T_m_180	0.2	0.8	5.7	0.1	36	36	100%	2.0	28.5	5.5
V_X_m_75	<2	63	108	2	36	35	97%	Min < LLD	Min < LLD	Min < LLD
V_X_m_180	<2	42	93	2	36	35	97%	Min < LLD	Min < LLD	Min < LLD
V_T_m_75	22	78	133	1	36	36	100%	22	6	111
V_T_m_180	13	59	118	1	36	36	100%	13	9	105
W_T_m_75	0.3	1.0	2.7	0.1	36	36	100%	3.0	9.0	2.4
W_T_m_180	0.2	0.6	1.1	0.1	36	36	100%	2.0	5.5	0.9
Y_M_m_75	10.70	19.45	65.50	0.01	6	6	100%	1070.00	6.12	54.80
Y_M_m_180	7.40	15.40	31.50	0.01	6	6	100%	740.00	4.26	24.10
Y_T_m_75	6.2	16.5	31.5	0.1	36	36	100%	62.0	5.1	25.3
Y_T_m_180	2.8	9.7	21.2	0.1	36	36	100%	28.0	7.6	18.4
Yb_M_m_75	1.26	2.09	6.30	0.01	6	6	100%	126.00	5.00	5.04
Yb_M_m_180	0.80	1.77	2.57	0.01	6	6	100%	80.00	3.21	1.77
Yb_T_m_75	0.6	1.9	3.2	0.1	36	36	100%	6.0	5.3	2.6
Yb_T_m_180	0.3	1.0	2.3	0.1	36	36	100%	3.0	7.7	2.0
Zn_X_m_75	<1	28	80	1	42	41	98%	Min < LLD	Min < LLD	Min < LLD
Zn_X_m_180	<1	17	65	1	42	37	88%	Min < LLD	Min < LLD	Min < LLD
Zn_T_m_75	6.5	39.2	90.8	0.2	36	36	100%	32.5	14.0	84.3
Zn_T_m_180	6.1	29.9	73.2	0.2	36	36	100%	30.5	12.0	67.1
Zr_X_m_75	149	433	1863	1	42	42	100%	149	13	1714
Zr_X_m_180	162	331	539	1	42	42	100%	162	3	377
Zr_T_m_75	19.2	89.3	153.6	0.2	36	36	100%	96.0	8.0	134.4
Zr_T_m_180	13.6	56.2	99.9	0.2	36	36	100%	68.0	7.3	86.3

Table 4. Continued.

*Parameter name: Analyte code_Method code_Unit code_Fraction code, as follows:
Analyte code: Cy = clay; St = silt; Sd = sand; pH15 = pH 1:5; EC15 = electrical conductivity 1:5;
LOI = loss on ignition; Ag = silver; etc.
Method code: L = laser particle size analyser; F = field (soil) pH; P = potentiometry; E = conductimetry;
M = ICP-MS at GA; T = ICP-MS at Acme; A = GF-AAS at ALS Chemex; X = XRF at GA;
I = ISE at ALS Chemex; Z = calculated based on XRF data; C = ICP-MS at CSIRO
Unit code: c = %, m = ppm; p = pH unit; u = uS/cm
Fraction code: Bk = bulk; 75 = <75 um; 180 = <180 um

4.1 Bulk regolith geochemistry

Maps showing the distribution of all measured geochemical parameters are given in Appendix 4.1. The map background represents the boundary of the catchments used here to determine sampling sites.

Maps for the TOS and maps for the BOS concentrations in the <180 um and <75 um fractions are presented, as are maps showing the distribution of the TOS:BOS ratio. The latter maps show where the concentrations of a given element are higher at surface than at depth (TOS:BOS > 1) and where they are lower (TOS:BOS < 1). These can be useful in interpreting the causes for elevated concentrations in certain places. Finally maps and diagrams comparing the <180 um and <75 um fractions are shown; these allow interpretation of the affinity of a certain element for either the finer (<75:<180 > 1) or the coarser (<75:<180 < 1) fraction of the TOS or BOS sample.

The maps are accompanied by several statistical diagrams: boxplots, scatterplots, cumulative frequency diagrams and histogram combined with density and smoothed frequency distribution plots of all the concentrations (TOS and BOS, <180 um and <75 um fractions).

Figure 14 shows the distribution of Au in the <75 μm fraction of the TOS samples from the Gawler pilot survey. Generally, at least one of the 4 regolith samples analysed from catchments where Au occurrences are known to exist shows elevated Au concentrations. In addition, several other high Au concentrations are found where no Au mineralisation is known to occur. These may deserve further investigation to determine the source(s) of these anomalies. Sheard *et al*. (2006) found that dunes in this region of South Australia are younger than 230,000 years. Sand dunes can contain calcrete (secondary carbonate accumulations in the near-surface regolith, generally as an indurated horizon), which, in turn, can contain anomalous Au (Lintern *et al*., 2006). This has been exploited as an exploration sampling medium (Butt *et al*., 1991; Lintern, 2002) in several areas of southern Australia. The implication of this maximum age for dune formation is that Au can migrate into stable transported cover and precipitate there in less than 220,000 yr (Sheard *et al*., 2006). Although the anomaly forming process is unclear, there is ample evidence from Australia to support relatively rapid (sub-)vertical Au migration into transported regolith blanketing Au mineralisation.

The distribution of Zn in the Gawler regolith (Figure 15) shows that elevated values (>~40 ppm) are generally found in the east and north of the study area, whereas nearly all Zn concentrations in the west are depleted. At first, this may appear to be due to dilution by aeolian materials, which generally tend to be more common in the west and certainly are the main surface material along the western edge of the study area. The facts, however, that there are several elevated Zn values in the northwest, and also that a sample with elevated Zn concentration is located in the middle of a dunefield in the west of the study area, suggest that there is more to this pattern than just a dilution effect. When compared to the solid geology, there appears to be a strong correlation between elevated Zn concentrations in regolith over Upper and Lower Gawler Range Volcanics, and low Zn concentrations in regolith over St Peters Suite Granite. These are two genetically distinct igneous suites, the former being an A-type and the latter an I-type suite (Skirrow *et al*., 2006).

The presence of (even small) mafic/ultramafic bedrock occurrences in the buried basement appears to correspond to elevated Cr concentrations in the overlying regolith, as shown in Figure 16. The Cr anomalies in the regolith do not always directly overly the bedrock (ultra)mafic body, as they are collected at catchment outlets, and can be displaced down-catchment.

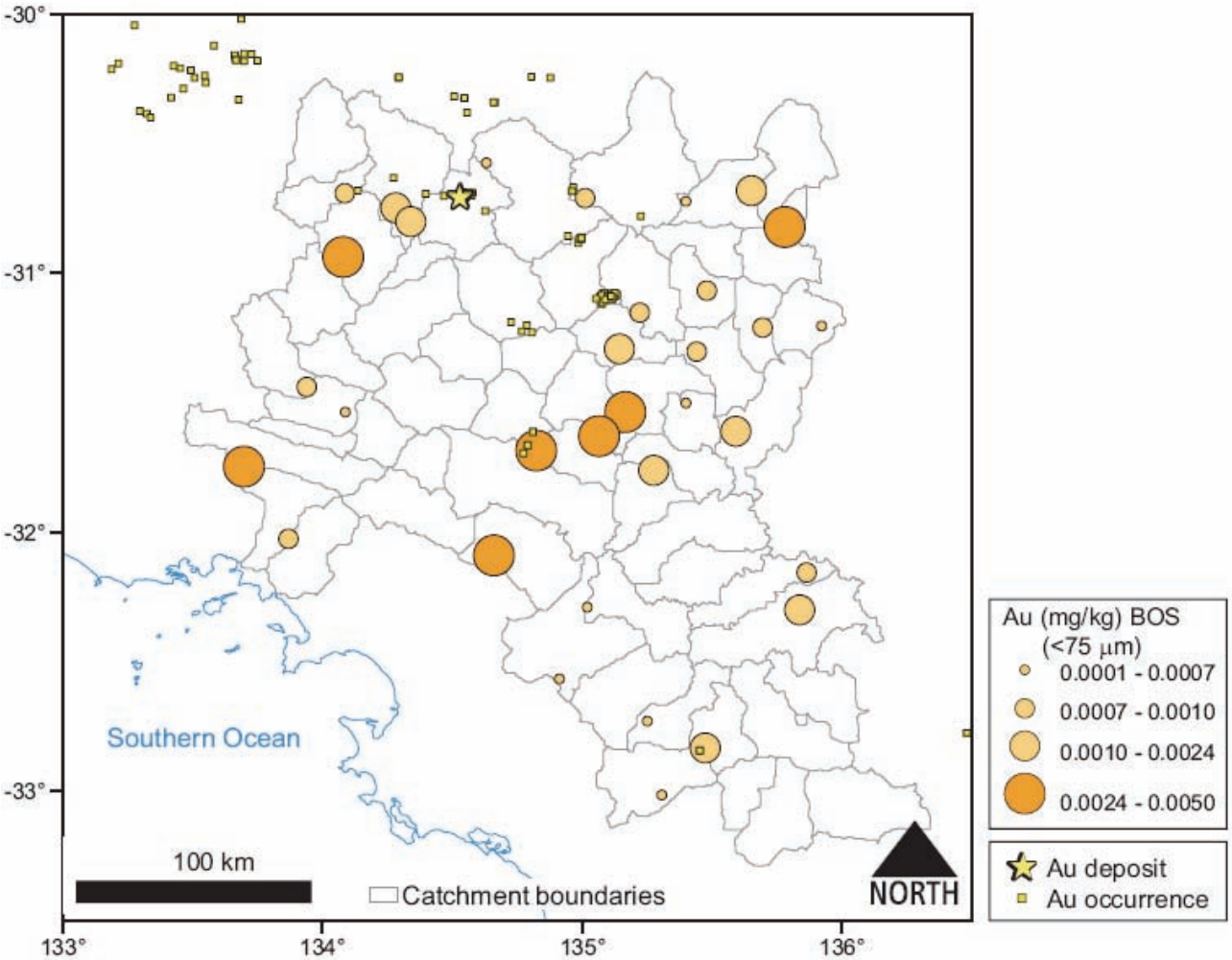


Figure 14. Distribution of Au (mg/kg) in the BOS (<75 um) samples of the Gawler region, also showing the location of known Au deposits and occurrences. Classes are quantiles.

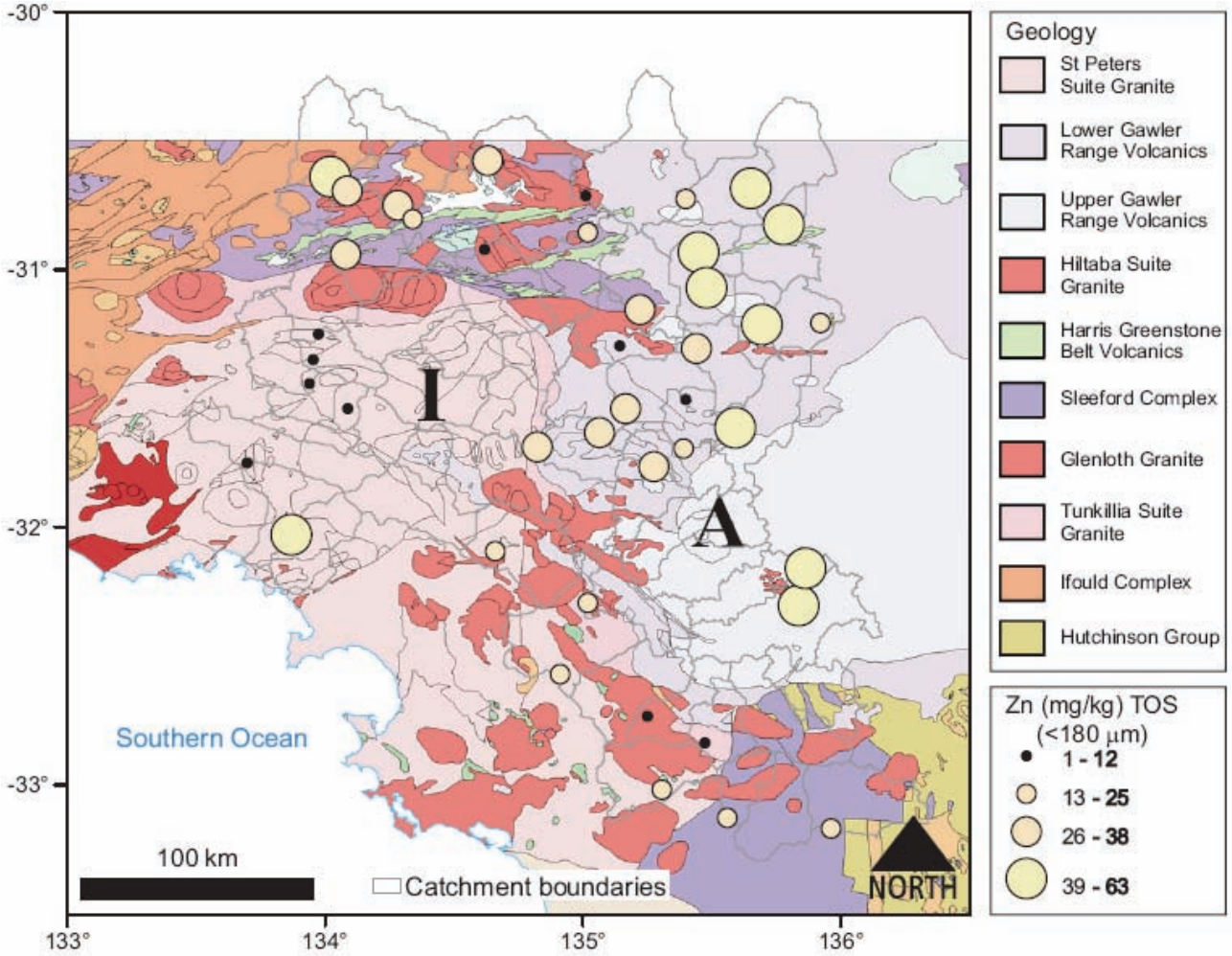


Figure 15. Distribution of Zn (mg/kg) in the TOS (<180 um) samples of the Gawler region, overlain on solid geology. Note the contrasting levels of Zn in regolith overlying A-type vs I-type intrusive rocks. Classes are quantiles.

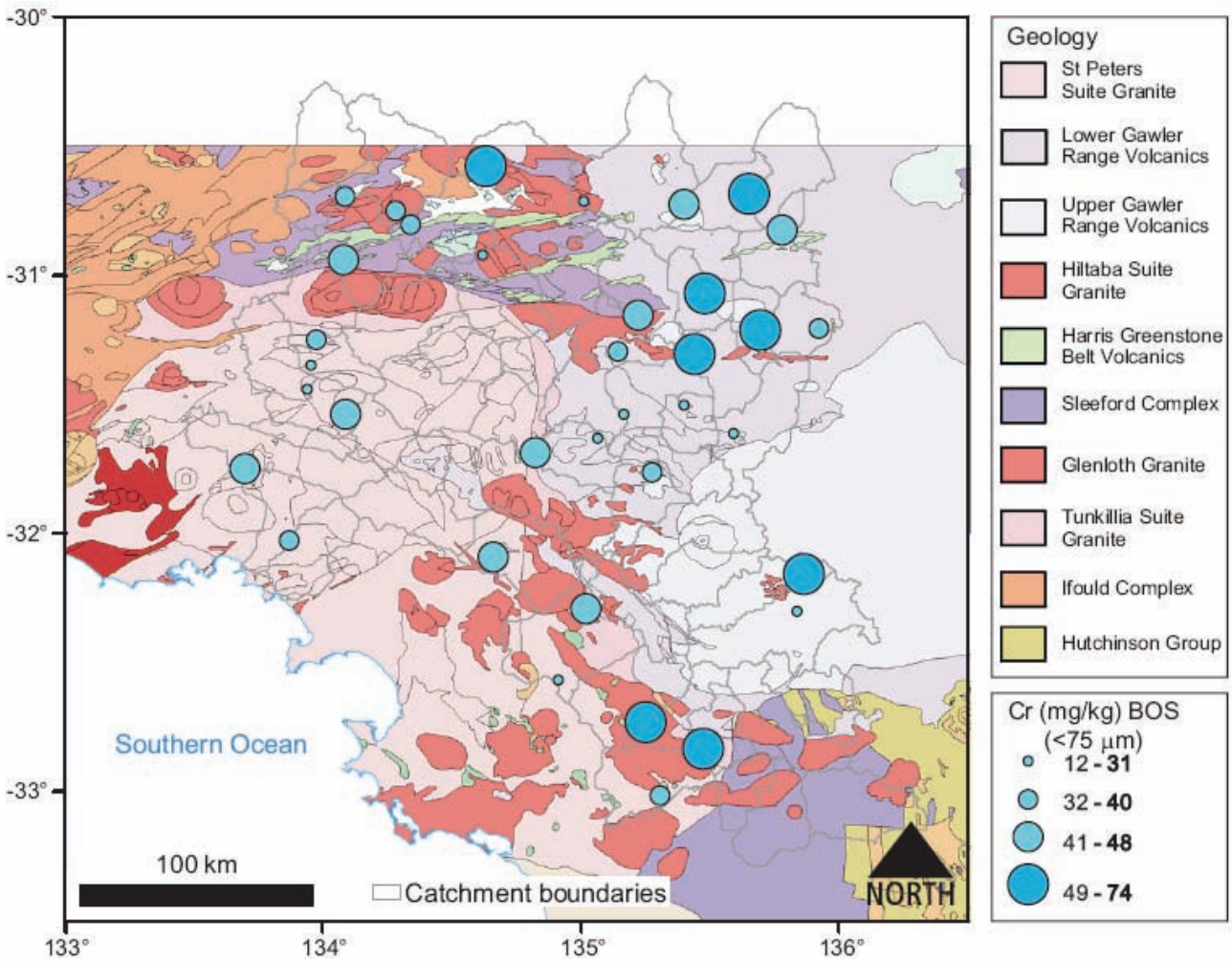


Figure 16. Distribution of Cr (mg/kg) in the BOS (<75 um) samples of the Gawler region, overlain on solid geology. Note that catchments containing even minor ultramafic bodies (green polygons) commonly exhibit elevated levels of Cr in the overlying regolith. Classes are quantiles.

4.2 Grain size analysis

Regolith samples from the TOS and BOS levels of the six sites sampled during the Reconnaissance trip were sieved to a series of grain-size fractions to determine where the elements tend to be concentrated more. The fractions separated are:

- <75 um
- 75-180 um
- <180 um
- 180-500 um
- 500-1000 um
- 1000-2000 um

Comparison of various grain sizes (Figure 17) indicates that the finer grain size fraction (<75 um) has significantly different (higher, in the chosen case of Cu) concentrations then all the other size fractions (the median of a population is significantly different from that of another when it is outside its notches, which are represented by square brackets). Thus, analysing 2 grain size fractions, one at <75 um and one coarser, e.g. <180 um, provides additional information (see Appendices 5.15, 5.16).

The other valuable information displayed by the diagram is that the variability between sites is much greater than the variability within sites (that is, between TOS and BOS, and between the 6 grain-size fractions, at any given site). This indicates that robust and meaningful geochemical patterns will emerge from this type of survey, even at ultra-low sampling densities. All that is required for useable geochemical maps to be produced is to select a sampling density that is appropriate for the size of the area under investigation.

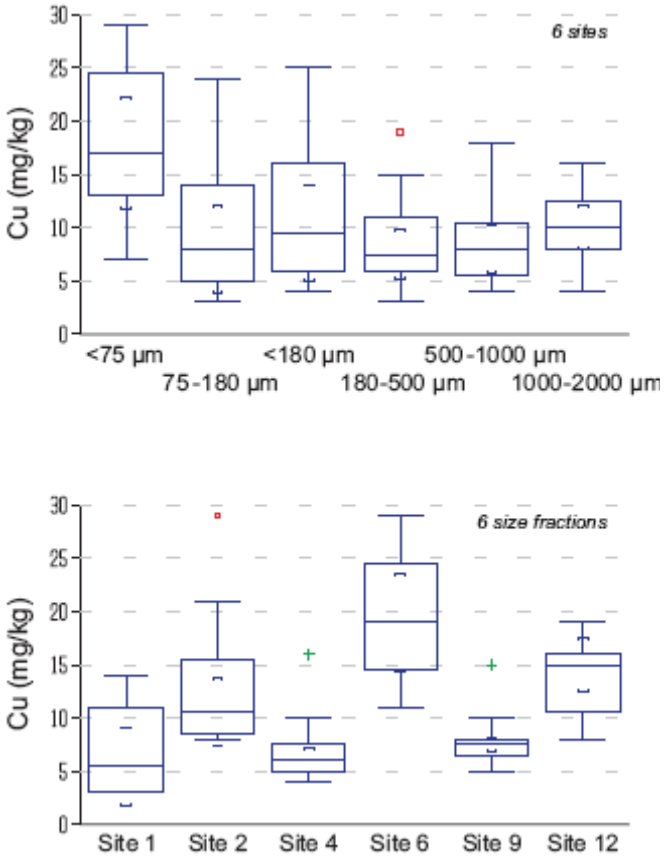


Figure 17. Boxplots of Cu concentrations (mg/kg) measured in 6 different size fractions at 6 different sites (at 2 depths: TOS and BOS) in the Gawler pilot project area (N = 12 for each population). (a) Five of the 6 size fractions are indistinguishable from one another across all sites, but (b) the sites are significantly different from one another regardless of grain size fraction. Median values of different populations are significantly different at the 5 % level when outside one another's notches, represented by square brackets; see Tukey (1977) and Velleman and Hoaglin (1981).

4.3 Mill contamination

The coarser grain size fractions discussed in the previous section (180-500 um, 500-1000 um, 1000-2000 um) were too coarse to allow production of XRF beads without grinding (milling) them. The standard milling procedure for these three coarse fractions was to use a carbon steel ring mill (from Rocklabs, New Zealand). In order to estimate the level of contamination that could result from this process, a few splits of these samples were also milled using a tungsten carbide ring mill from the same manufacturer. According to a study by Webber *et al.* (2008) using various mills for various lengths of time, the carbon steel mill can add 2500-3400 ppm Fe, 2-5 ppm Cr, 2 ppm Cu and 1.2-2.2 ppm Ni to a pure quartz sample (a very abrasive material). Conversely, these authors found that tungsten carbide milling can add 110-160 ppm Co and 900-1300 ppm W to a pure quartz sample.

Our comparative results of these two types of mill (Table 5) overall support these findings: we found that

1. on average, the carbon steel mill added a few ppm of Cr and Cu and about 1200 ppm Fe (relative to tungsten carbide), and
2. on average, the tungsten carbide mill added a few tens of ppm of Co and a few hundreds of ppm of W, but barely affected the Ni concentrations (relative to carbon steel).

Table 5. Comparison between samples milled with carbon steel (first line; CS) and tungsten carbide (second line; TC) for contaminants determined by Webber *et al.* (2008). LLD = lower level of detection.

SampleID	Site	Zone	Fraction	Co_X_ppm	Cr_X_ppm	Cu_X_ppm	Fet_X_ppm	Ni_X_ppm	W_X_ppm
06001D	06	1	D	23	36	13	18799.872	9	44
TC06001D	TC06	1	D	73	33	11	17128.306	10	536
Diff				50	-3	-2	-1671.566	1	492
06001E	06	1	E	15	23	11	13750.204	7	42
TC06001E	TC06	1	E	91	20	8	11218.376	6	655
Diff				76	-3	-3	-2531.828	-1	613
06001F	06	1	F	18	25	11	16009.266	7	43
TC06001F	TC06	1	F	89	30	10	16477.864	9	674
Diff				71	5	-1	468.598	2	631
09002D	09	2	D	15	20	7	14253.772	1	48
TC09002D	TC09	2	D	59	17	5	13638.3	1	301
Diff				44	-3	-2	-615.472	0	253
09002E	09	2	E	19	22	8	23478.858	1	50
TC09002E	TC09	2	E	48	23	5	23653.708	1	271
Diff				29	1	-3	174.85	0	221
09002F	09	2	F	21	18	8	25094.472	1	51
TC09002F	TC09	2	F	54	19	5	28220.79	1	336
Diff				33	1	-3	3126.318	0	285
12002D	12	2	D	57	113	15	58819.54	28	49
TC12002D	TC12	2	D	78	108	14	57441.722	28	247
Diff				21	-5	-1	-1377.818	0	198
12002E	12	2	E	64	125	15	68226.47	30	49
TC12002E	TC12	2	E	87	121	15	66554.904	30	219
Diff				23	-4	0	-1671.566	0	170
12002F	12	2	F	77	143	16	87620.832	29	51
TC12002F	TC12	2	F	84	133	15	81326.232	29	181
Diff				7	-10	-1	-6294.6	0	130
Min Diff				**7**	**-10**	**-3**	**-6295**	**-1**	**130**
Ave Diff				**39.3**	**-2.3**	**-1.8**	**-1155**	**0.2**	**332.6**
Max Diff				**76**	**5**	**0**	**3126**	**2**	**631**

Note: Values <LLD have been halved (= 0.5 LLD)
Diff = TC value - CS value
D: 180-500 um
E: 500-1000 um
F: 1000-2000 um

4.4 FeO versus Fe_2O_3

A few samples from the Gawler and Thomson (Caritat and Lech, 2007) geochemical surveys were selected for FeO determination (by standard titrimetric methods). The results (Table 6, Figure 18) indicate that the assumption that most Fe (90-100 %) present in the regolith samples is in the form of oxidised Fe is warranted.

Table 6. FeO and Fe2O3 concentrations in selected samples from the Gawler (this study) and the Thomson (Caritat and Lech, 2007) pilot geochemical surveys.

Sample	FeO%	Fe2O3(Tot)%	Size Frac	Fe(II) %	Fe(Tot) %	Fe(II) proportion
Gawler						
20058511082	0.228	2.851	<75um	0.1772244	1.9939894	9%
20058511102	0	2.918	<180um	0	2.0408492	0%
20058511181	0.299	4.622	<75um	0.2324127	3.2326268	7%
20058511241	0.083	3.039	<180um	0.0645159	2.1254766	3%
Thomson						
2005861002001	0.059	4.895	<75um	0.0458607	3.423563	1%
2005861009001	0.056	3.36	<180um	0.0435288	2.349984	2%
2005861014002	0.07	4.768	<75um	0.054411	3.3347392	2%
2005861017002	0.179	3.482	<180um	0.1391367	2.4353108	6%

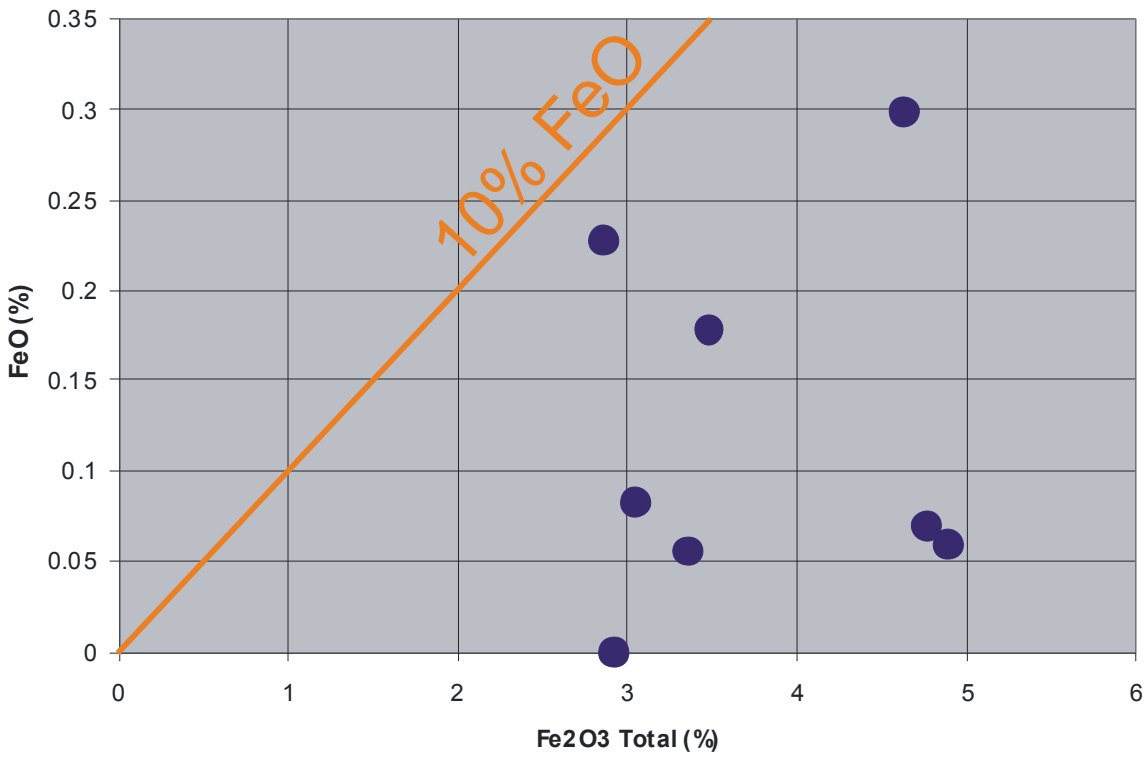


Figure 18. Scatterplot of FeO versus Fe2O3 Total in 8 samples from the Gawler and Thomson geochemical survey.

4.5 Heavy mineral analysis

Only 4 samples from the Gawler survey were analysed by AutoGeoSEM (Appendix 5.6). These represent 3 different sites; at 1 site, heavy mineral fractions from both TOS and BOS were analysed for comparison. Results have to be viewed in light of the limited size of this dataset (more heavy mineral results were obtained from the Riverina geochemical survey; see Caritat *et al.*, 2007).

In general, non-magnetic heavy mineral fractions are dominated by Fe oxides. Other significant phases identified are Ti and Zr rich. These results are consistent with those from the Riverina geochemical survey (Caritat *et al.*, 2007).

4.6 Munsell soil colour

TOS and BOS soil colours were recorded for both dry and moist conditions in the field using the Munsell colour scheme (Munsell Color Company 1975). Some sites were too moist at the time of sampling to record a dry colour. The Munsell soil colours are recorded in Appendix 5.7 and one example map shown in Figure 19.

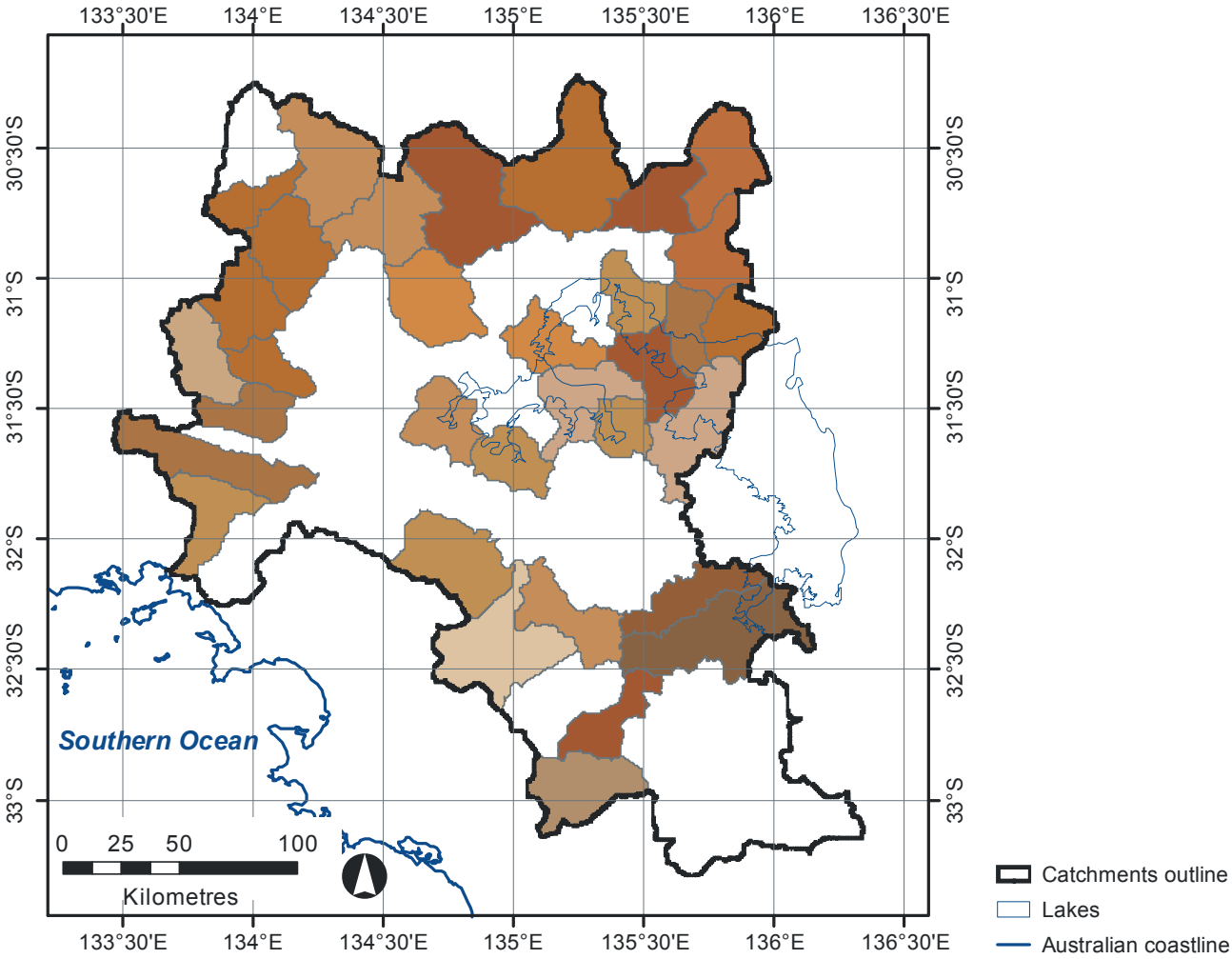


Figure 19. Munsell soil colour distribution in dry BOS samples extrapolated from sampling point at bottom of catchment to whole catchment.

4.7 pH

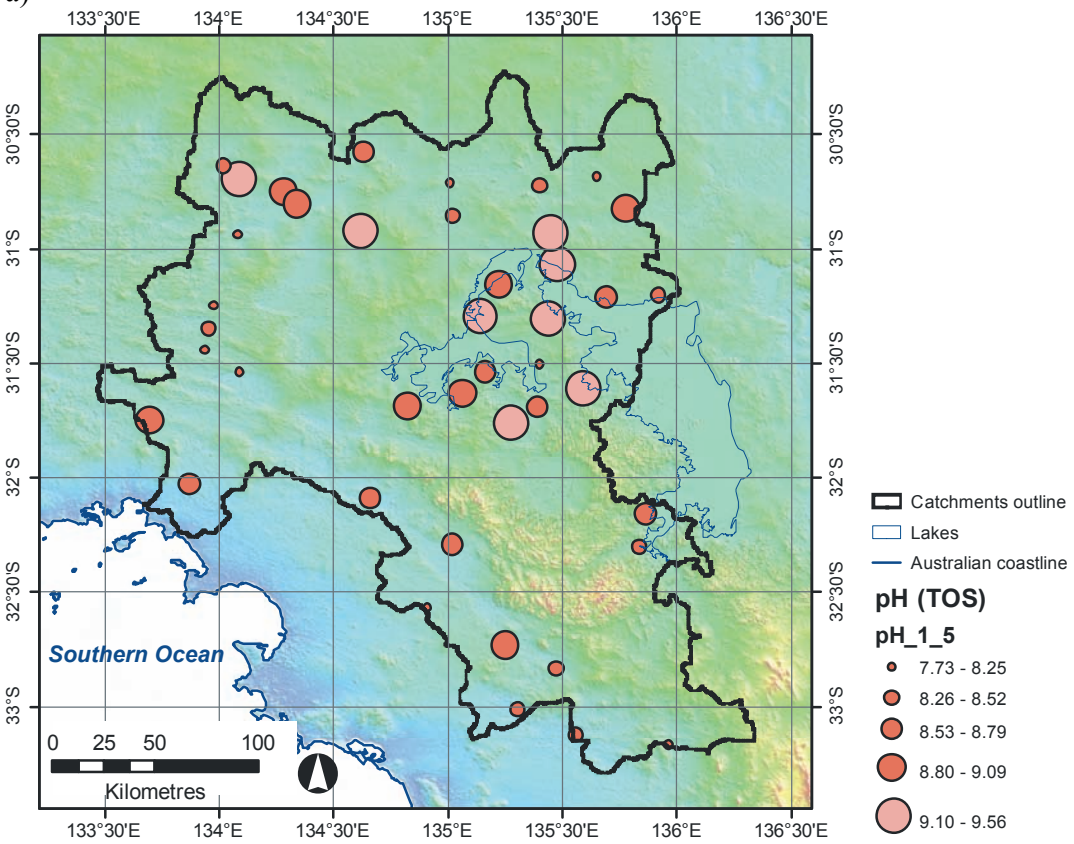
The soil pH was recorded in the field for both the TOS and the BOS samples (Appendix 5.7). In the laboratory, pH of a 1:5 (soil:water) solution was measured also for both the TOS and the BOS samples (Figure 20). The agreement between field and lab (1:5) pH values is not particularly good (Figure 21), compared for instance with an R^2 value of 0.6 and slope of 0.7 in the Riverina geochemical survey (Caritat *et al.*, 2007). All those data are presented in Appendix 5.7. Higher pH values are broadly observed in the central E and N of the area, but there are a few scattered high pH values recorded elsewhere.

4.8 Electrical conductivity

The electrical conductivity of 1:5 (soil:water) solutions (EC 1:5) was measured in the laboratory. The data are presented in Appendix 5.7. Maps of the distribution of EC 1:5 (Figure 22) show that the soil solutions are the most conductive (a proxy for salinity) in the central E and N of the area, with the TOS displaying also a coastal overprint (sea salt deposition).

A plot of EC 1:5 vs pH 1:5 (Figure 23) illustrates that there is no clear relationship between the two parameters; both the most acid (pH < 6) and the most alkaline (pH > 8) soils encountered occur in the mid range of the salinity values (~50-200 uS/cm).

a)



b)

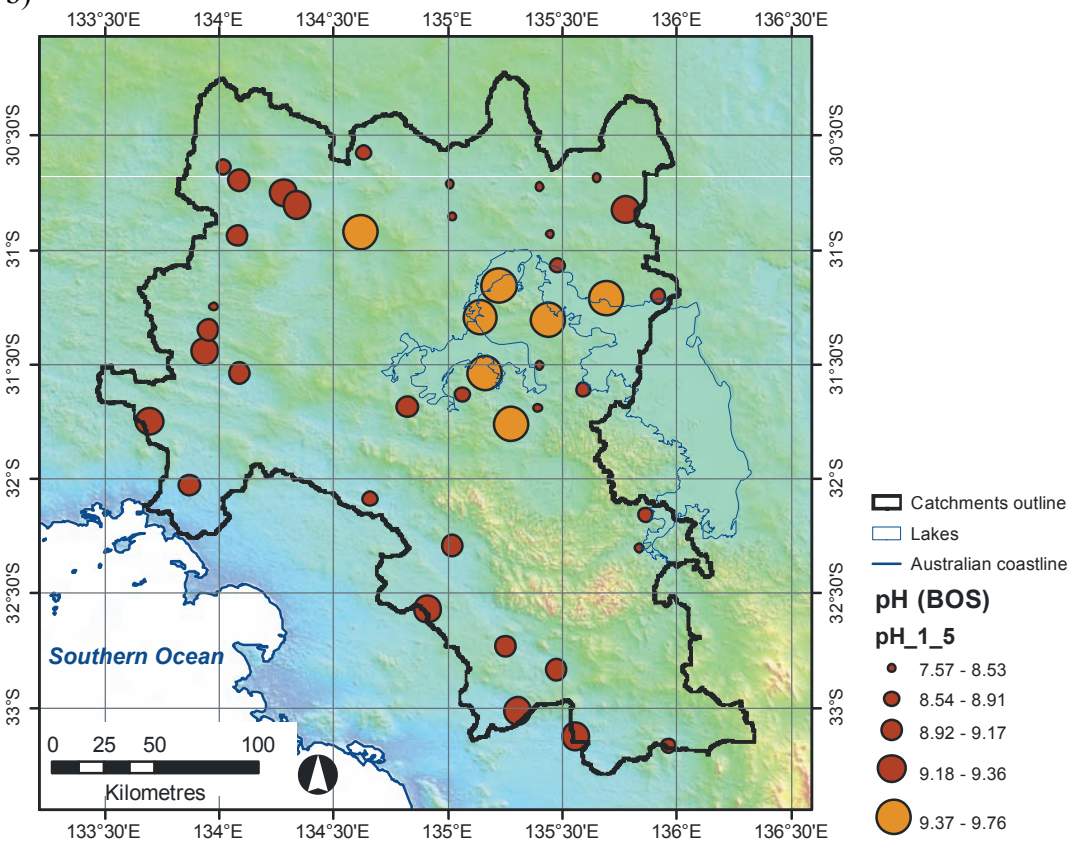


Figure 20. pH 1:5 for TOS (a) and BOS (b) samples from the Gawler geochemical survey. Classes are quantiles.

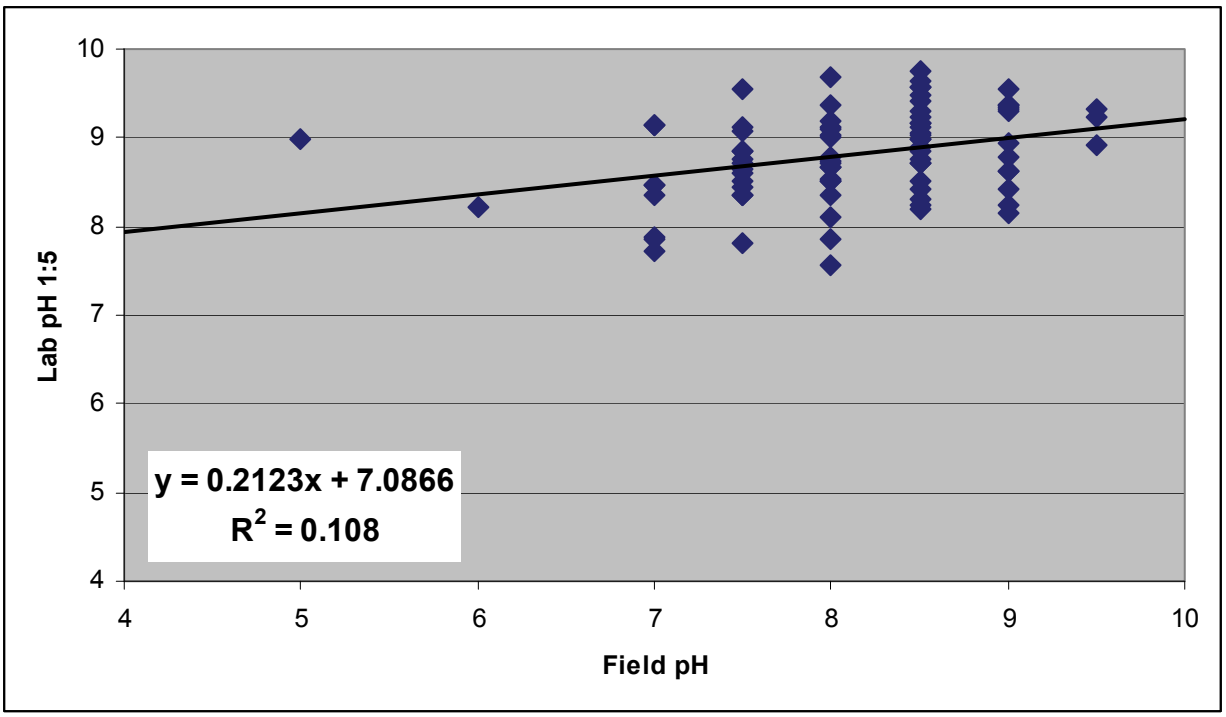


Figure 21. Scatterplot of pH 1:5 vs field pH for TOS and BOS samples from the Gawler geochemical survey.

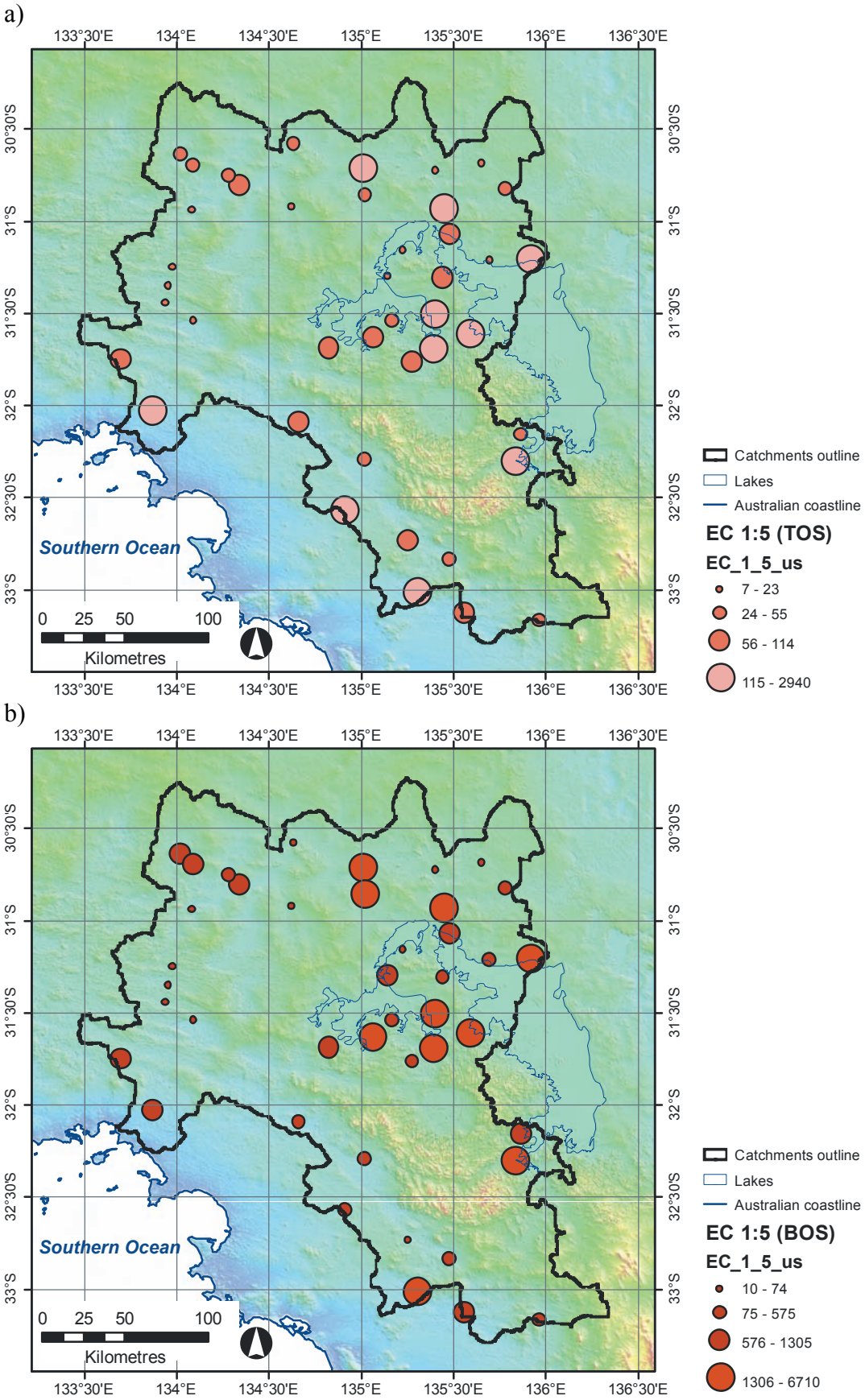


Figure 22. EC 1:5 for TOS (a) and BOS (b) samples from the Gawler geochemical survey. Classes are quantiles.

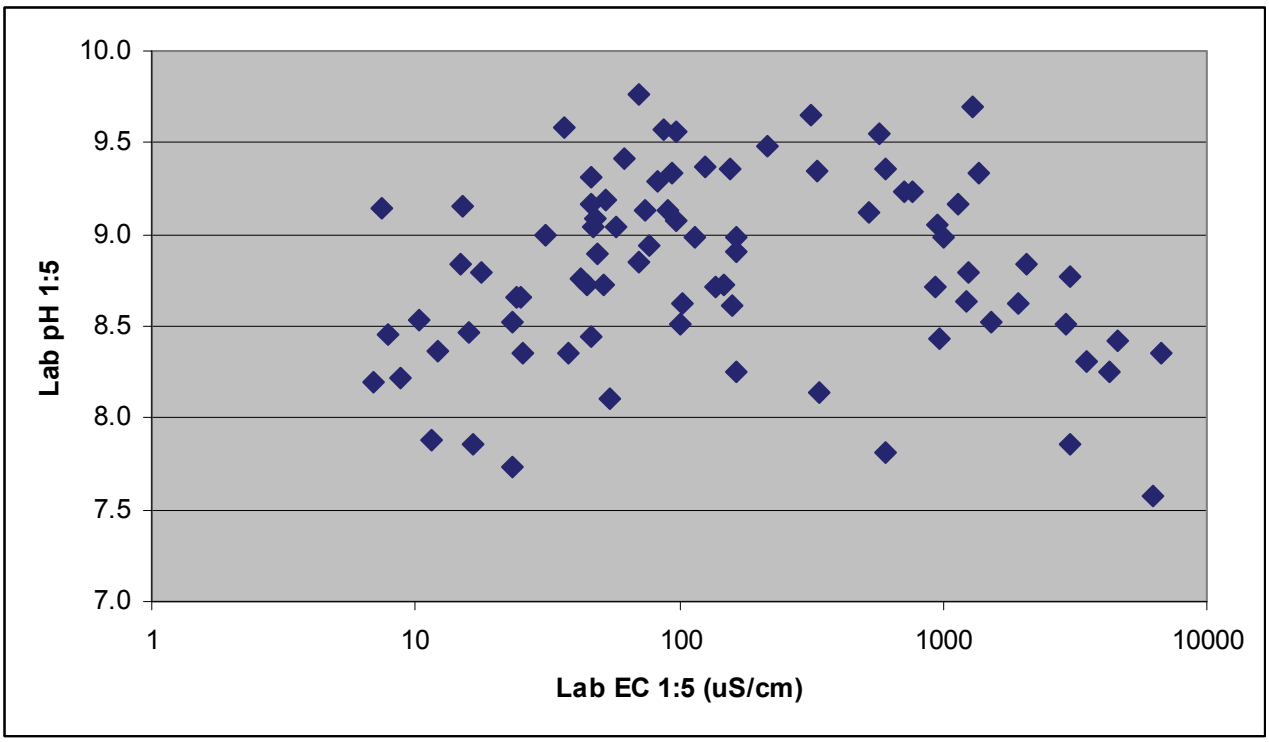


Figure 23. Scatterplot of pH 1:5 vs EC 1:5 (uS/cm) for TOS and BOS samples the Gawler geochemical survey. Note the log axis for EC 1:5.

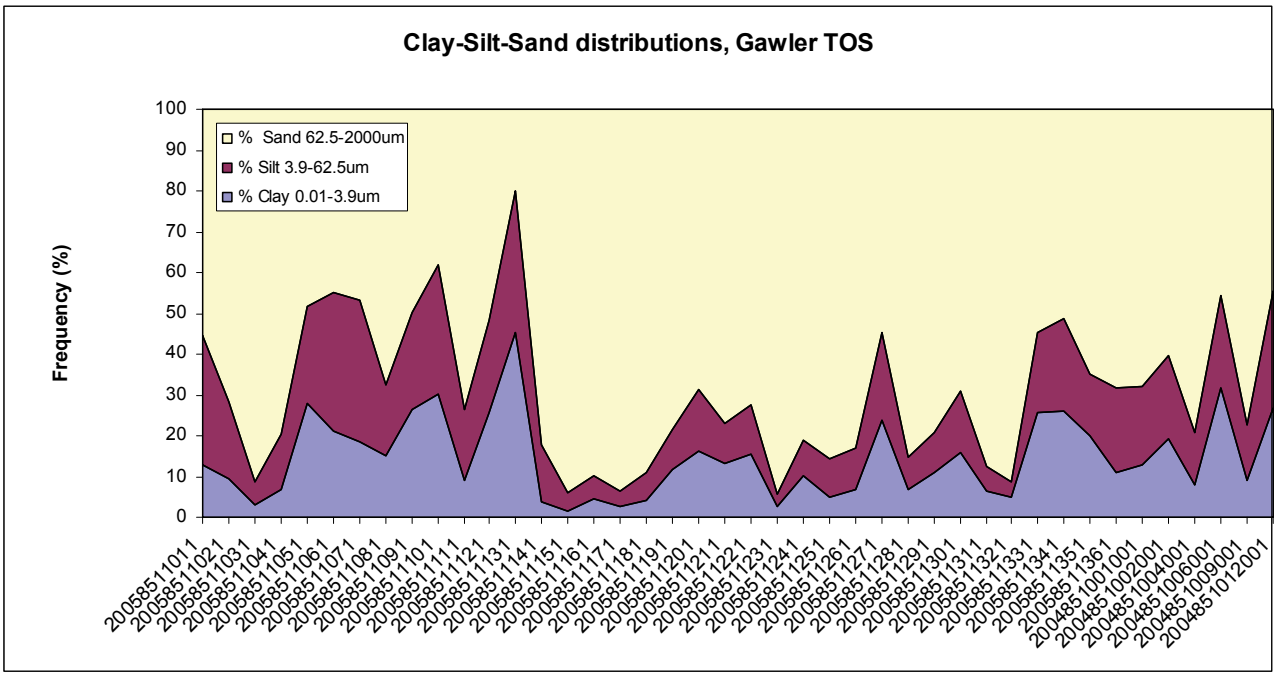
4.9 Laser particle size analysis

Understanding the grain size composition is important as it has vast implications for the chemical behaviour of the sediment, and where and how elements are likely to be distributed within the sediment.

The grain size composition for the Gawler varied between clayey soils (e.g. 20058511272 with 52 % clay, 16 % silt and 32 % sand) to sandy soils (e.g. 20058511031 with 3 % clay, 6 % silt and 91 % sand) (Figure 24). Samples with high amounts of sand are theoretically avoided by the very methodology of siting the sampling location on floodplains, however, the scarcity of drainage systems and the importance of sand dunes in the landscapes of the study area (see above) is obvious in the grain size distribution. Overall, the TOS and BOS samples from the Gawler have an average (± 1 σ) grain size distribution of 18 % (± 13 %) clay, 18 % (± 9 %) silt and 65 % (± 20 %) sand.

Most samples from the Gawler survey show a bimodal grain-size distribution with the greatest abundances around 150-600 um (medium sand) and 2-4 um (clay); BOS samples also have minor peaks at 0.5-1 um (fine clay) (Figure 25).

a)



b)

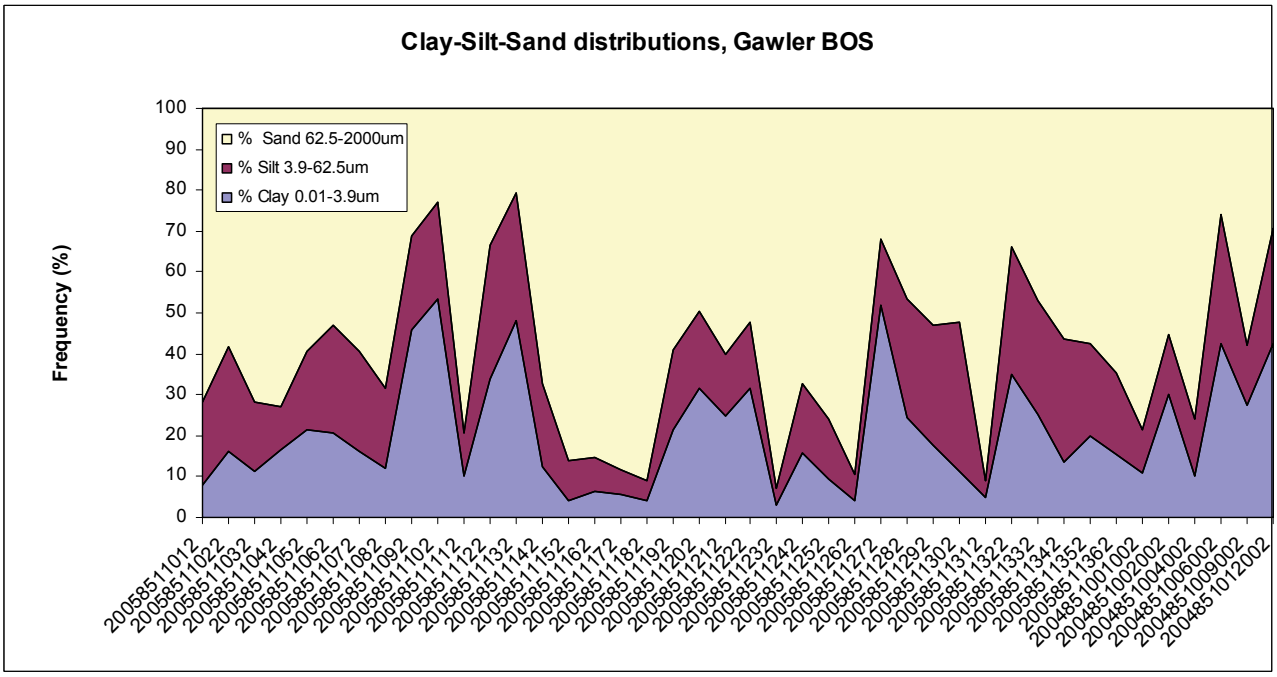


Figure 24. Clay (<4 um), silt (4-62.5 um) and sand (62.5-2000 um) distribution of the Gawler TOS (a) and BOS (b) samples.

a)

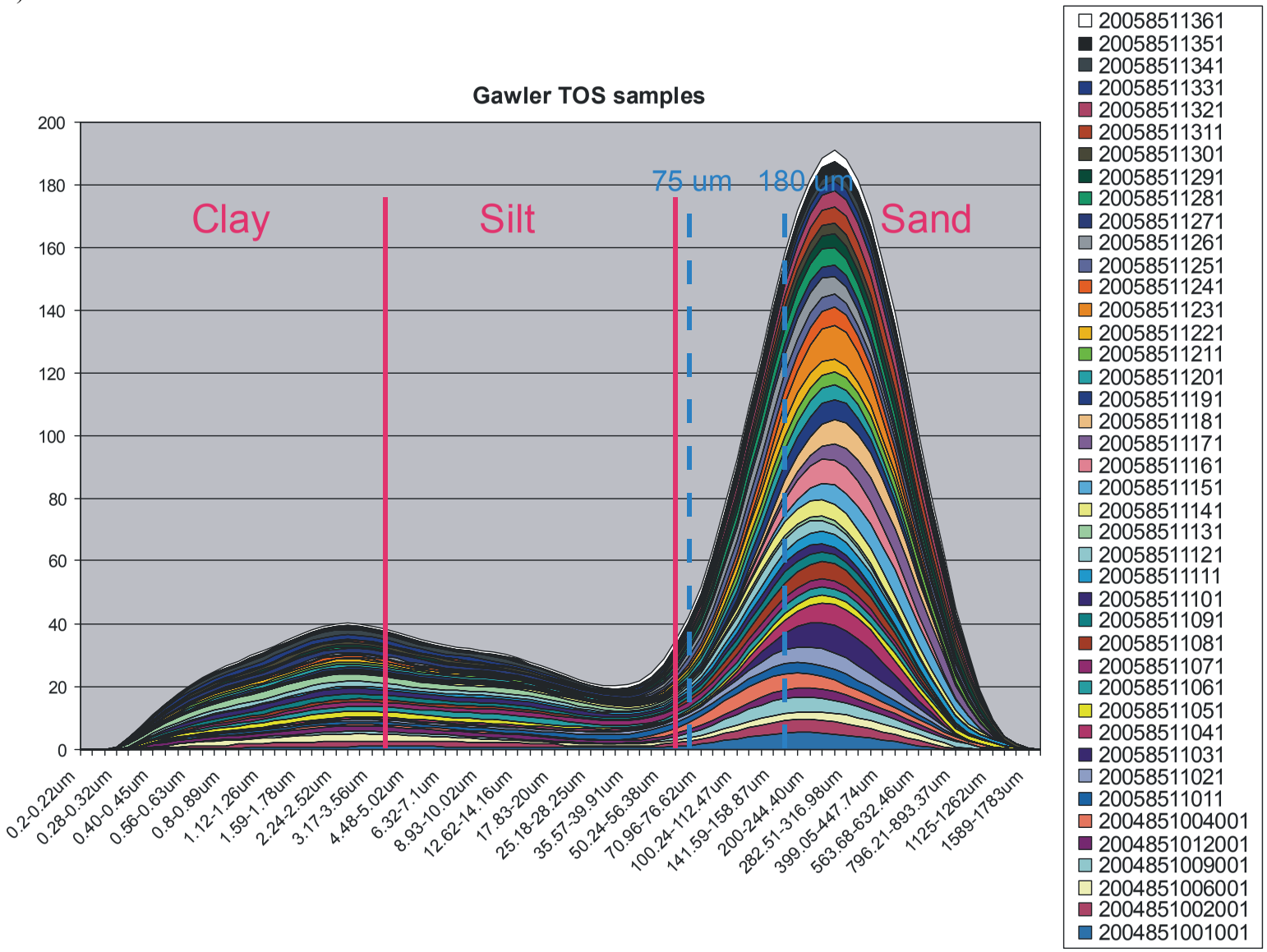


Figure 25. Particle size distribution for all TOS (a) and BOS (b) samples from the Gawler geochemical survey. The vertical scale is Frequency (%).

b)

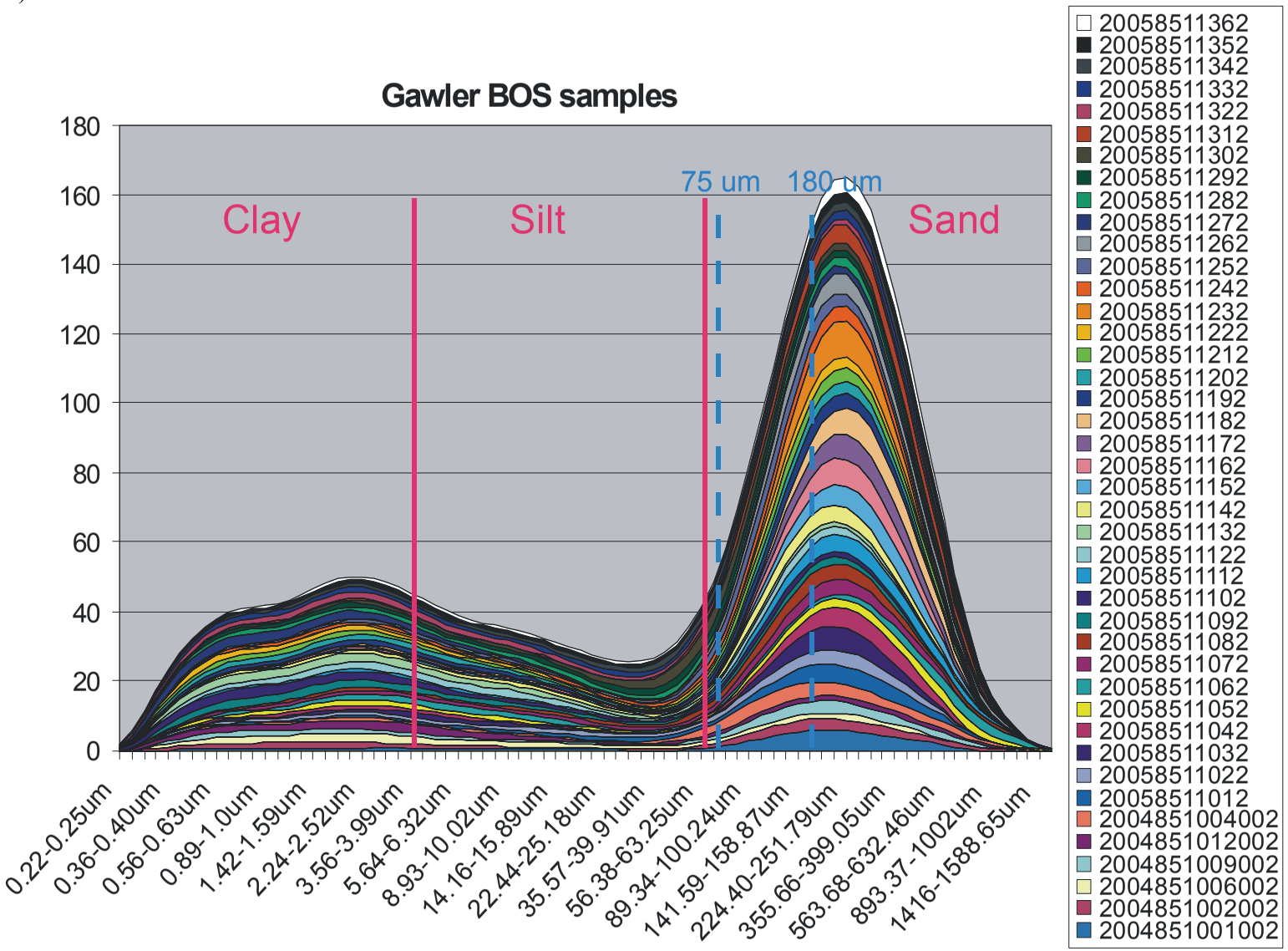


Figure 25. Cont'd.

4.10 Groundwater

4.10.1 Charge Balance

One common test for analytical reliability of data can be preformed by calculating the overall charge balance (electro neutrality, EN) based on the equation (all values in meq/L):

$$EN = \{(\Sigma_{cations} - \Sigma_{anions}) / (\Sigma_{cations} + \Sigma_{anions})\} * 100$$

The EN is represented as a % fraction, with ranges of -10 % to +10 % generally being acceptable. Only samples with sufficiently complete major element analysis can give meaningful results from this test (Na^+, K^+, Ca^{2+}, Mg^{2+}, Cl^-, SO_4^{2-}, HCO_3^- and/or CO_3^{2-}). Data that has full major analysis and has a neutral charge balance for the sum of the major ions can be relied upon as having been analysed sufficiently well to be able to draw conclusions from interpretations. This test is not always suitable for very fresh samples where ion concentrations are small, and therefore possibly large relative errors can exist for ion concentrations. It is also not suitable in some samples where there are larger proportions of 'non-major' ions that could influence the electro neutrality test. Results from this study are presented in Table 7 and Figure 26.

The 6 samples collected during the reconnaissance trip in 2004 did not have field alkalinity titrations and thus field levels of HCO_3^- cannot be determined. Despite the lack of this anion, 7 of the 8 analytical samples (including the 2 analytical duplicates) fall within acceptable ranges -10 % to +10 % EN. This is due to their high overall salinity, and therefore the dominance of Cl^- and Na^+ ions in the charge balance equation. All reconnaissance samples had larger values for the sum of the cations compared to the sum of the anions, and this may be due to the absence of field HCO_3^- measurements. A fresher sample taken from a windmill pumping water for a household dam has an EN value of -43 %, at least partly due to the absence of HCO_3^- value, as at lower salinities, this anion becomes more significant to charge balance calculations. This sample is likely to be a mixture of rainwater and groundwater, and has a TDS of 179 mg/L, compared to the median of all the groundwater samples at 4921 mg/L. All the other groundwater samples analysed from the main field trip fall within acceptable EN ranges.

Table 7. Water types, bulk parameters and charge balance (Electro Neutrality, EN) for groundwaters from the Gawler survey.

SampleID	Station	Water Type	calc TDS mg/l	pH	Temp °C	Eh mV	Sum cations meq/l	Sum anions meq/l	E.N. %
G003	Wilgena Homestead Dams	Na-Ca-Cl	179	8.3	21.0	na	4	2	-43
G005		Na-Cl	5630	7.3	22.3	na	76	81	-1
G007	Payminers Well NE	Na-Ca-Cl	2188	7.6	22.9	na	31	31	-6
G008	Horse well	Na-Cl	3446	8	24.0	na	50	51	-4
G010		Na-Cl	11422	6.8	22.0	na	176	182	-1
G011	Yardea Home Bore	Na-Ca-Cl	3923	6.9	21.7	na	54	62	-3
201	Yardea Home Bore	Na-Ca-Cl	4121	6.9	21.3	263	52	66	2
202	Teatree	Na-Cl	4842	7.3	22.7	239	66	75	1
203	? Near to Nuckulla	Na-Cl	6854	7.3	21.2	164	91	107	6
204	Black Hill Well	Na-Cl	13341	7.1	22.4	187	190	218	2
205	Milda	Na-Cl	7742	7.1	25.2	230	103	128	7
206	Hiern Well	Na-Cl	9338	8.2	24.3	-29	136	151	2
207	Claysons Well	Na-Cl-HCO3	1928	7.9	23.2	150	23	25	1
208	Geologists Well	Na-Ca-Cl	4919	7.6	21.6	167	59	80	1
209	Mullina Well	Na-Cl	4416	7.5	21.8	-28	56	69	3
210	Campbells bore (new)	Na-Ca-Cl	4921	7.1	24.0	247	62	75	2
211	Welcome Well	Na-Cl	7192	7.4	23.5	235	101	116	4
212	Carters Well	Na-Ca-Cl	7361	7.3	22.8	223	95	119	2
213	North Well	Na-Cl	5300	7.3	22.9	232	70	84	3
214	New Monties Well	Na-Cl	6965	7.1	21.6	232	94	112	2
215	Chanda Booka Well	Na-Cl	10006	7.1	23.2	241	146	160	0
217	Mulga no 2	Na-Ca-Cl	2884	8.4	20.7	249	36	42	2
218	Cooks Dam	Na-Cl	9667	7.7	21.3	247	132	154	2
219	Charlotte Well	Na-Ca-Cl	1999	8.6	22.6	242	23	28	2
220	North Swamp Well	Na-Cl-HCO3	1837	8.1	21.7	256	22	24	1

Minimum		179	6.8	20.7	-29	4	2	-43
Median		4921	7.3	22.4	232	66	80	2
Maximum		13341	8.6	25.2	263	190	218	7

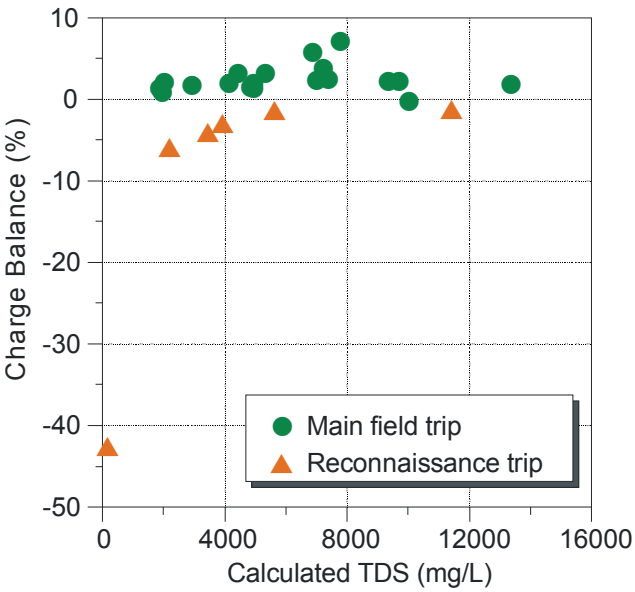


Figure 26. Scatterplot of charge balance versus Total Dissolved Solids (TDS) for groundwaters from the Gawler survey. Samples from the Reconnaissance trip were not analysed for alkalinity (HCO_3^-).

4.10.2 Bulk parameters

Groundwaters collected in the Gawler region (Table 7) have near neutral pH values (6.8 to 8.6) and range from brackish to saline conditions with total dissolved solids (TDS) of ~1800 to 13,300 mg/L, with a median of 4921 mg/L (excluding a relatively fresh sample taken from a homestead dam, G003).

Temperatures of waters were low and fairly homogeneous, ranging from 20.7 to 25.2 °C (median 22.4 °C).

Only samples on the Main field trip were analysed for Eh but results show for those locations a range from -29 to 263 mV, with a median of 232 mV (all relative to Standard Hydrogen Electrode or SHE). Only 2 sites had strongly reducing values, and these warrant further investigation, especially in regards to ferrous ion and sulfide concentrations, as well as Dissolved Oxygen (DO) and metal ion concentrations.

Waters are mainly of the Na-Cl type (14 of 25 samples), followed by Na-Ca-Cl (9 of 25) and Na-Cl-HCO_3^- (2 of 25) types (see Table 7, Figure 27, Figure 28). The groundwaters from the Main trip are fairly high in dissolved oxygen (0.1 to 8.5 mg/L, Figure 29).

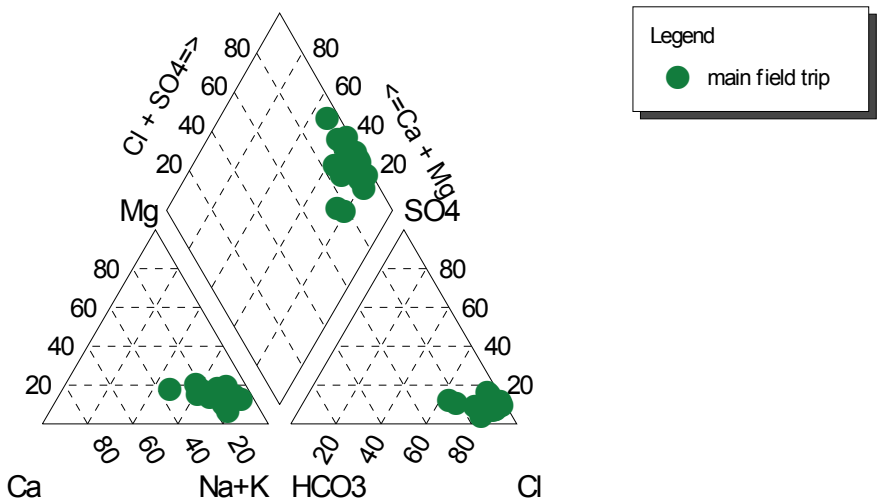


Figure 27. Piper plot of Gawler samples. Note: the 6 samples taken on the Reconnaissance trip do not show on this plot as they were not analysed for HCO_3^-.

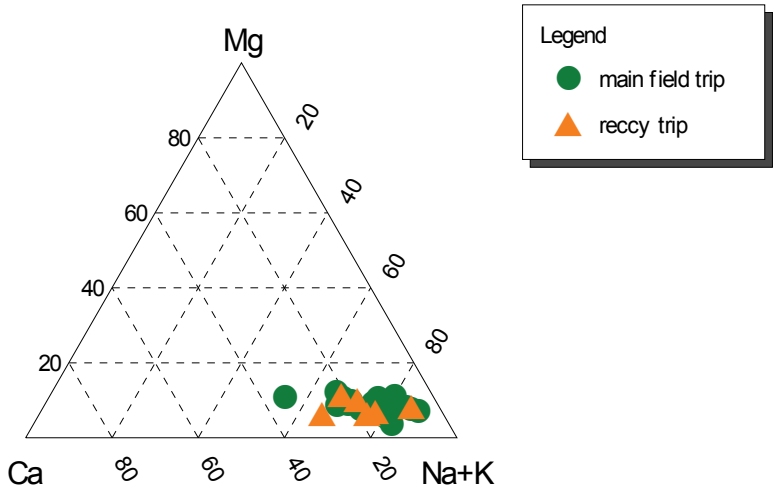


Figure 28. Cation ternary plot of Gawler samples, including Reconnaissance trip samples, indicating similar character in Ca, Mg, Na and K concentrations between the two sample groups.

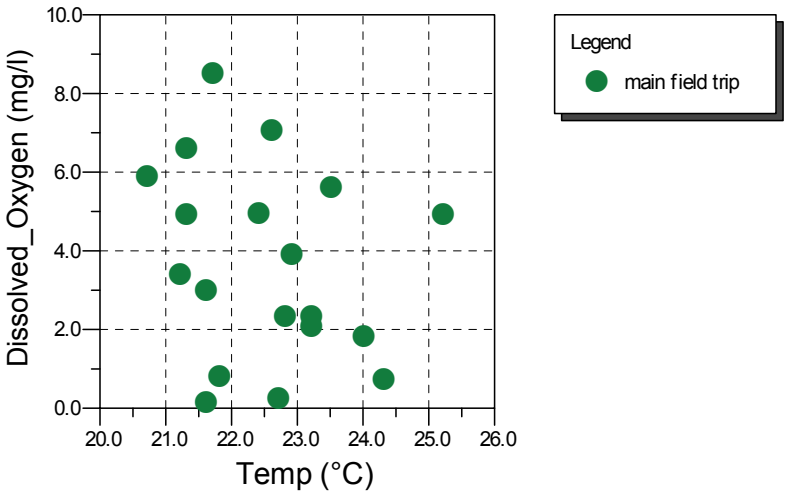
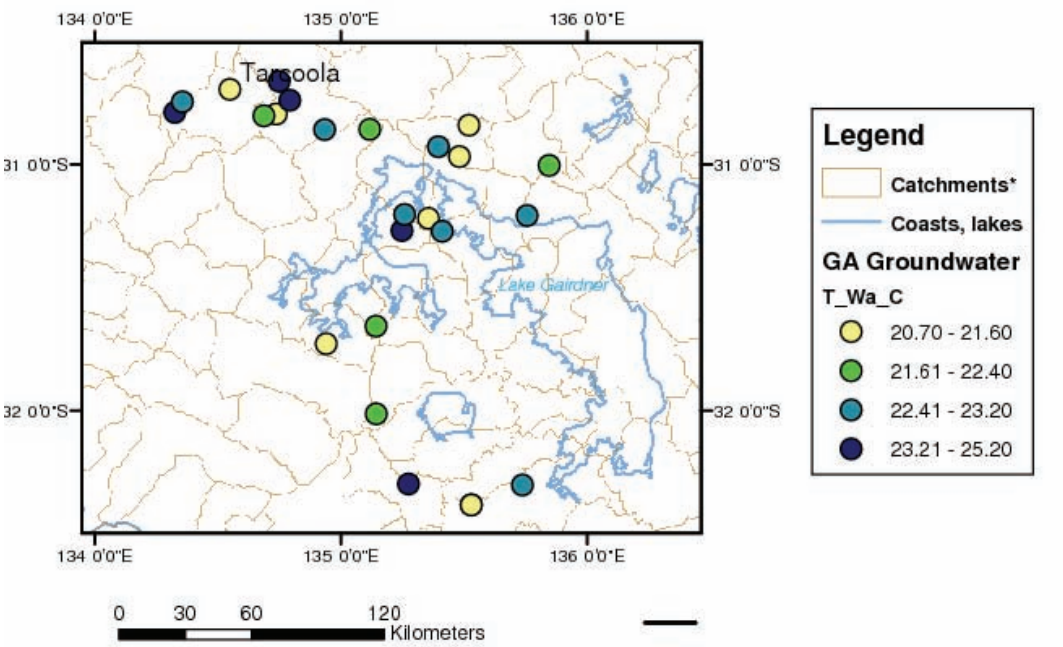


Figure 29. Scatterplot of Dissolved Oxygen (DO) vs Temperature. Note that reconnaissance samples are not shown because they were not analysed for DO.

4.10.3 Geochemical maps

The geographic distributions of water temperature, pH, electrical conductivity, Eh and dissolved oxygen are shown in Figure 30, Figure 31, and Figure 32.

a)



b)

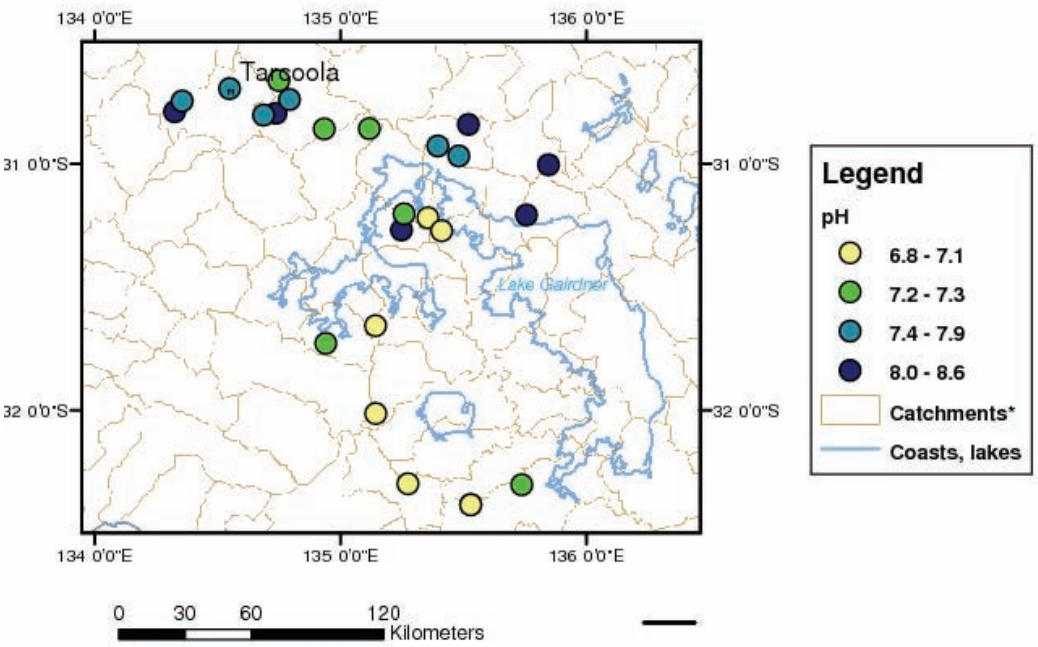


Figure 30. Water temperature (°C; a) and pH (b) distribution for groundwater samples from the Gawler geochemical survey. Classes are quantiles.

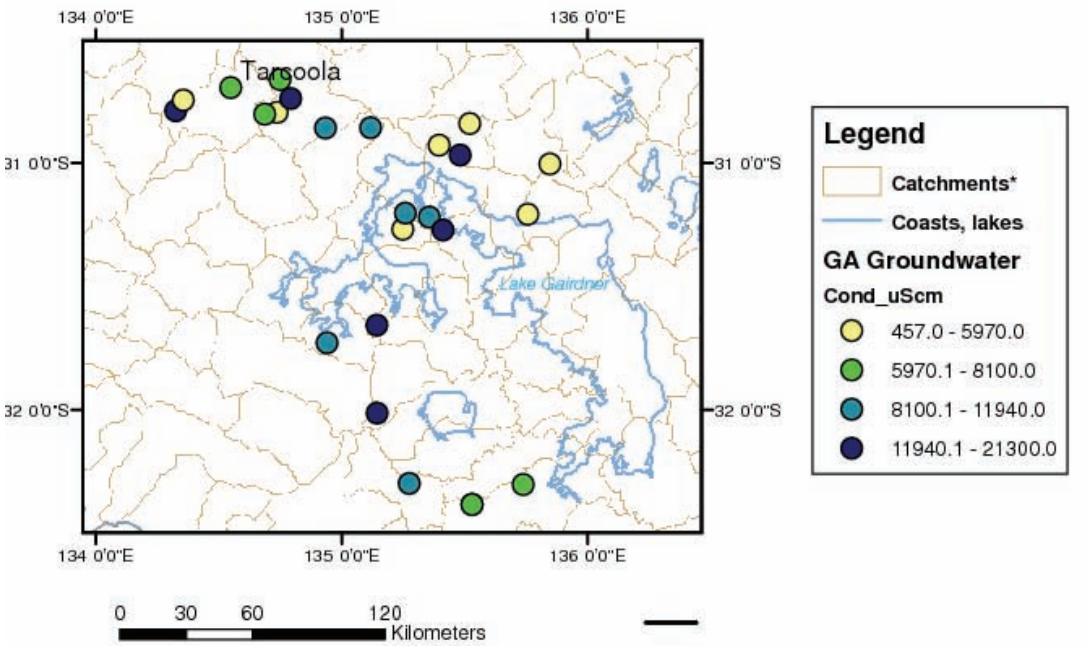
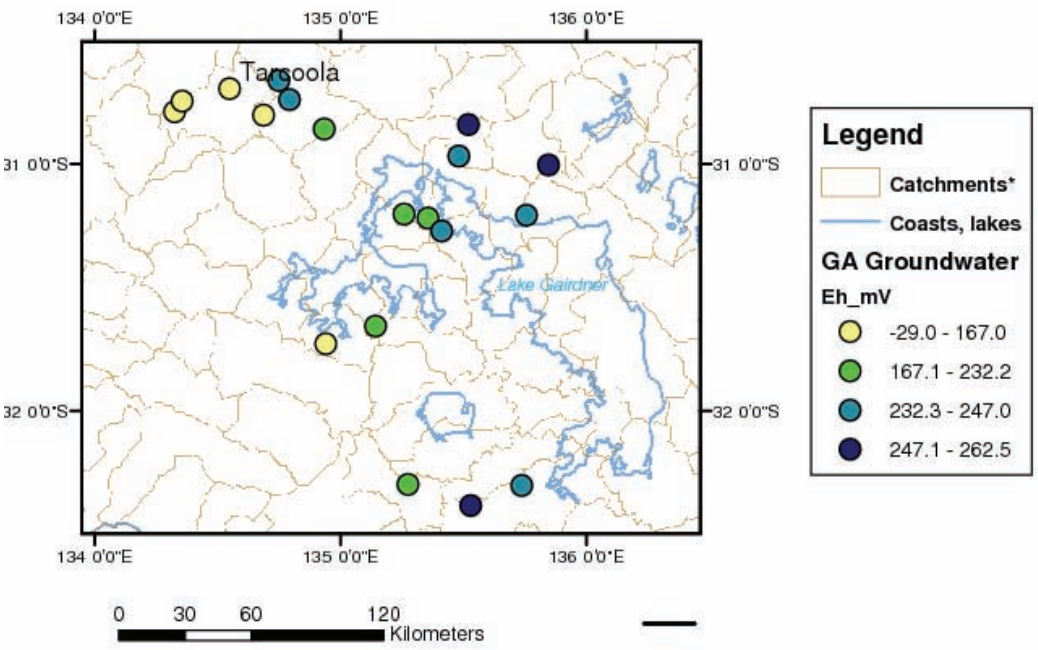


Figure 31. Electrical conductivity (uS/cm) distribution for groundwater samples from the Gawler geochemical survey. Classes are quantiles.

a)



b)

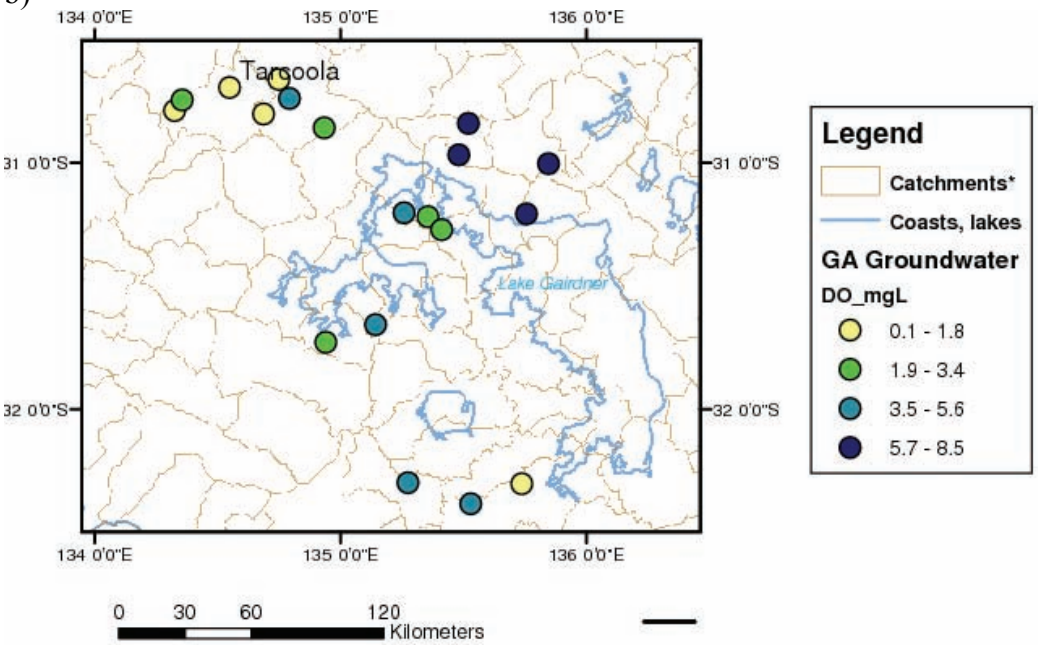


Figure 32. Eh (mV SHE; a) and dissolved oxygen (mg/L; b) distribution for groundwater samples from the Gawler geochemical survey. Classes are quantiles.

The geographic distributions of As concentrations in groundwater is shown in Figure 33. Although not many catchments with known Au occurrences and deposits could be sampled for groundwater, there are some indications that where groundwater is sampled close to (or down gradient from) such places, the pathfinder As tends to be elevated in groundwater.

The evidence shown by both the As in groundwater (Figure 33) and the Au in regolith (Figure 14 and Appendix 4.1) suggests that the area just north of Lake Gairdner could be prospective for Au mineralisation.

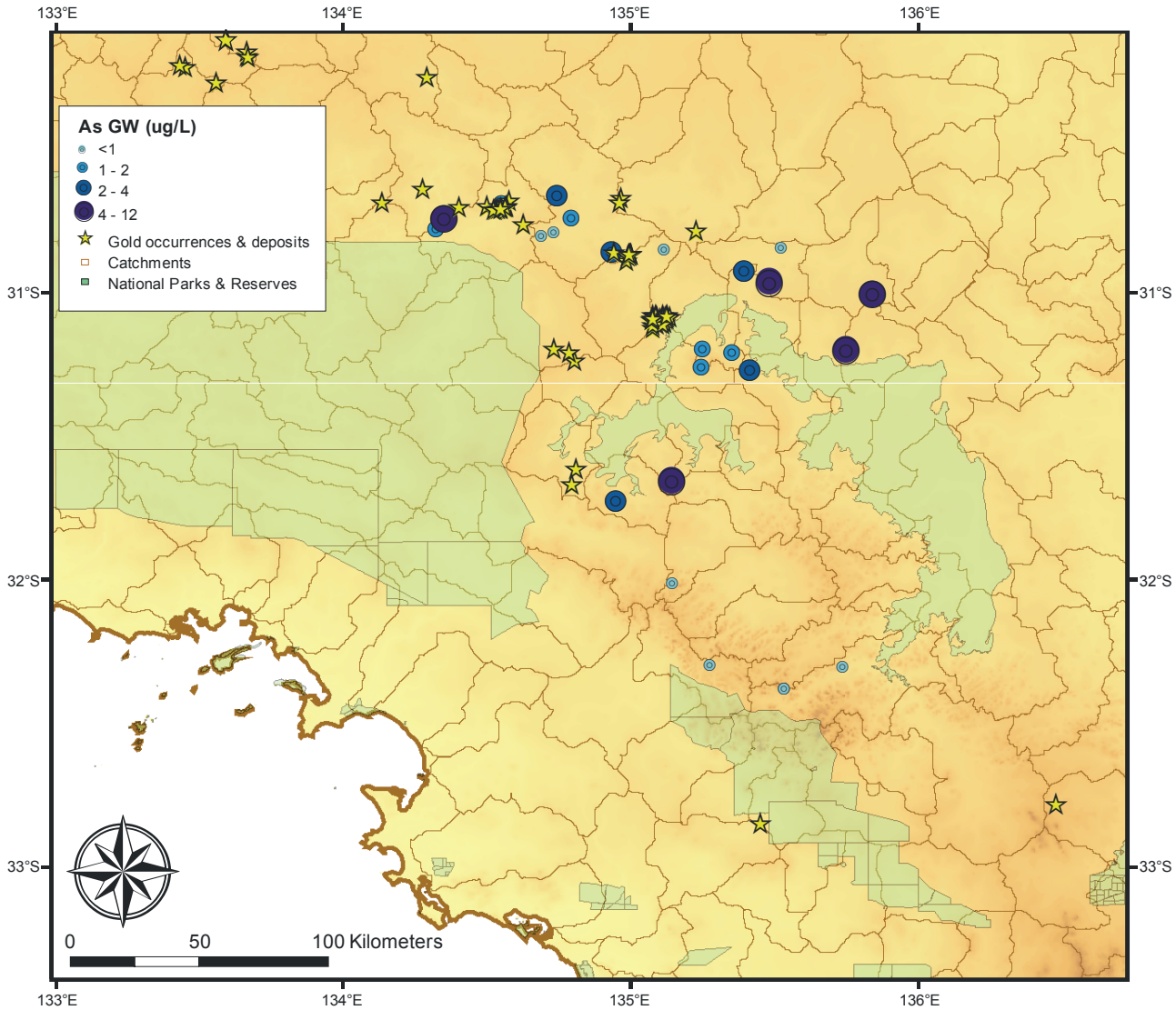


Figure 33. As concentration in groundwater samples from the Gawler geochemical survey together with known Au occurrences and deposits. Classes are quantiles.

5 CONCLUSIONS

The Gawler geochemical survey has demonstrated that:

1. Outlet sediments, which are found both in bedrock and regolith dominated terrains, and over much of Australia, constitute a pragmatic and useful sampling medium for future low-density geochemical surveys, even in areas where aeolian materials dominate;
2. Survey areas can be divided into catchments of an appropriate size to yield a sufficient, yet not excessive, number of sampling sites;
3. Terrain and hydrological modelling can be used to rapidly generate theoretical target sites near the outlet of those catchments, without recourse to user bias or decision-making;
4. By sampling outlet sediments both at the surface and at depth, useful information can be gained on potential mechanisms to explain the sources and sinks of elements as well as on potential temporal changes;
5. The <75 um fraction of outlet sediments minimises dilution by sand grains (dominated by quartz) and thus yields enhanced levels of concentration (fewer detection limit problems) and higher contrasts (higher signal-to-noise ratios);
6. Bedrock characteristics relating to lithology (e.g., A-type and I-type intrusive bodies, ultramafic rocks) and mineralisation (e.g., Au) can be determined from low-density geochemical surveys targeting the overlying, sometimes thick and often transported regolith;
7. The Au concentrations found in regolith in the Gawler study area suggest that several catchments without currently known Au occurrences may well host Au mineralisation;
8. Chemical analysis of groundwater sampled at low spatial density yields information on transport of elements within the regolith and may be useful to complement exploration programs;
9. Low-density, cost-effective and useful information in terms of mineral and natural resource assessment and monitoring can be obtained by surveys such as this.

6 ACKNOWLEDGMENTS

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APPENDICES

8 APPENDIX 1. ARCHYDRO METHOD TO DETERMINE THEORETICAL SAMPLING SITES

Methodology for selecting sample points using the Arc Hydro 1.1 Beta 2 extension in ArcGIS

Datasets used: Version 2 of the national 9 second Digital Elevation Model (DEM), Australian Nested Catchments and Sub-Catchments at 500 km^2 scale.

The national DEM was used to ensure that future geochemical surveys are fully comparable. NB: The DEM was not reconditioned as it is corrected using topographic information including drainage lines and point elevation data, and consequently is a robust dataset. This step may be useful for DEM's captured in airborne geophysical surveys. National Nested Catchments (500 km^2 scale) from the Centre for Resource and Environmental Studies (CRES) at the Australian National University were used instead of defining our own catchments with ArcHydro. This ensures that the dataset is fully comparable across the whole of Australia.

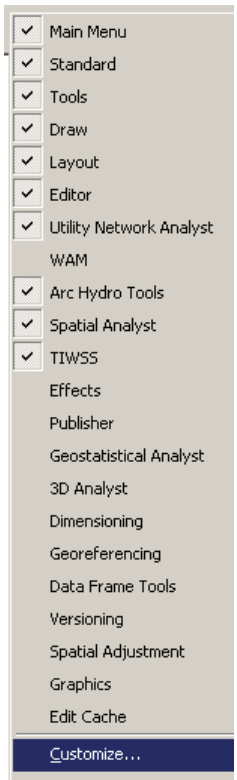
Installation of the ArcHydro Extension

To be able to use the ArcHydro extension, the ArcInfo licence of the ArcGIS software is a requirement. The ArcHydro 1.1 Beta 2 extension was downloaded from http://www.crwr.utexas.edu/gis/gishydro03/ArcHydroTools/ArcHydroTools.html

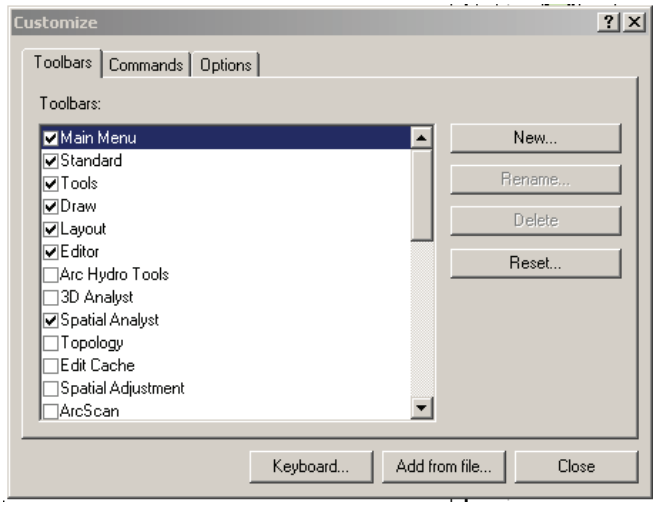
To install the toolbar:

1. Run the ArcHydro tools setup. After double-clicking the setup, browse to the desired installation location (use default location). The necessary files will be installed in the bin directory under the destination folder.

2. Open ArcMap. Right mouse click on the menu bar and scroll to "Customize."

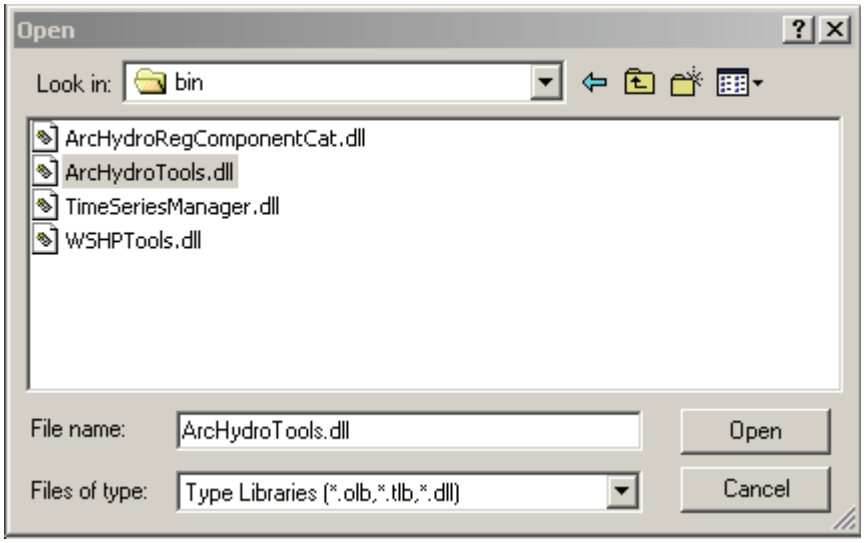


3. Click “add from file” when the Customize dialog box appears.

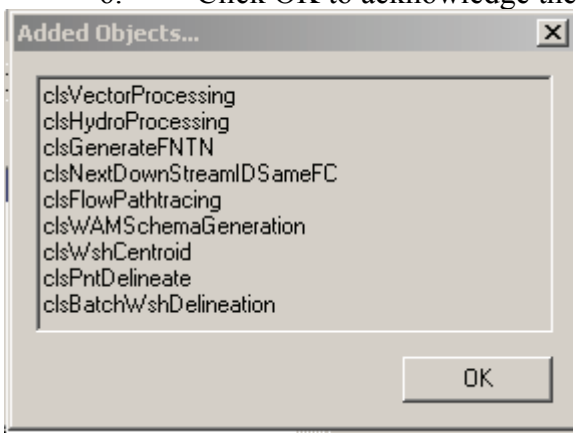


4. Browse to the location of ArcHydroTools.dll. In this case, the .dll was located at: C:\Program Files\ESRI\ArcHydro

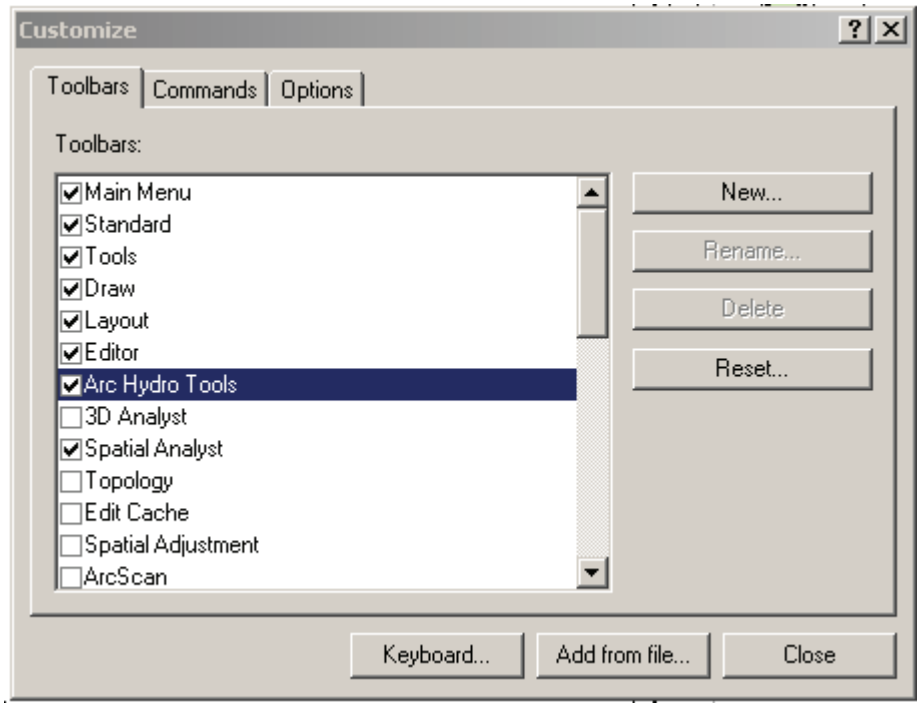
5. Select ArcHydroTools.dll and click Open to add to the Toolbar



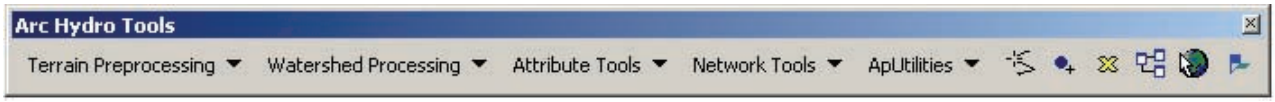
6. Click OK to acknowledge the additions of the new objects



7. The ArcHydro toolbox should now appear as a toolbar



8. The ArcHydro Toolbar should now appear.



9. The Spatial Analyst Extension needs to be activated, by clicking Tools>Extensions…, and checking the box next to Spatial Analyst

Derivation of the Sampling Points

To get the sample points, follow the steps below:

10. **Fill the sinks**: Terrain Processing>Fill Sinks. (rivdemv2_fil). This function fills the holes in the grid. If a cell is surrounded by higher elevation cells water flows in but cannot flow out. By filling the sinks, the elevation is raised to prevent this problem from occurring.
11. **Flow direction**: Terrain Processing>Flow Direction. (fdir_rivdem2)
    Insert the relevant DEM and name the output file. The values in the cells of the flow direction grid indicate the steepest decent from that cell – hence the flow direction.
12. **Flow Accumulation:** Terrain Processing>Flow Accumulation. (fac-rivdem2). ArcHydro takes the flow direction grid and determines the flow accumulation grid.
13. **Drainage Point Processing**: Before this can be done, the nested catchments layer from CRES (CAT500) needs to be converted to a grid using the spatial analyst extension: Spatial Analyst>Convert>Features to Raster. The field needs to be ID, and the output cell size is 0.0025[1]. To obtain the drainage points: Terrain Processing>Drainage Point Processing. Insert the DEM and the catchment grid. The resultant points should be that the outlet points for each of the catchments. Check to ensure that there are not points in the middle of the catchments etc.

The first lot of drainage points were selected by following the whole process from start to finish. These points were then regenerated only redoing step 4. It was noted that the drainage points that were created were slightly different than the first lot of points generated. It is hypothesised that by creating the drainage points, the flow accumulation grid is modified slightly. This needs to be tested to ensure that when the process is repeated from start to finish that the same result can be achieved more than once.

Culling sample points for the Gawler Low Density Survey

This methodology used to cull points for the low density survey was similar to that used for the Riverina region (see Caritat *et al.*, 2007).

[1] This cell size was used as the 9 second grid spacing is in longitude and latitude approximates to 250 metres.

9 APPENDIX 2. Field Form

Method of digging hole:

REGIONAL GEOCHEMICAL SURVEY
OVERBANK SEDIMENT SAMPLING

SAMPLE ID **2004 75 1 ☐* __ __ __**

Date ____/____/_____ (dd/mm/yyyy)
Sampler/Team _____

LOCATION REGION: NRBR_____ MAPSHEET _____
STREAM NAME _____ NEAREST TOWN _____
SHIRE _____ PROPERTY _____

Zone _____ Latitude _____ Longitude _____
Datum _____ Way Pt. _____ Altitude _____ m

DESCRIPTION OF CATCHMENT BASIN

Approx size of catchment _____ (hectares / km^2) Catchment ID _____ (ANU catch500)
Predominant bedrock lithology within catchment basin _____

SITE DESCRIPTION

Landscape/topography _____
Land use
- □ Agriculture, specify crop _____
- □ Pasture, grassland, fallow field
- □ Forest □ Native _____ □ Plantation _____ □ Other _____
- □ Wetland
- □ Not-cultivated
- □ Urban
- □ Other, specify _____

River width _____m depth_____m
Channel Characteristics □ Natural □ reinforced
□ Man-made (ditch, irrigation channel)
Time since last rainfall ____ days ____ hours
Stream flow □ Dry □ Flowing □ Flooding
Bedrock lithology _____
Outcrops □ Yes, specify _____
□ No
Grain size _____% silt-clay _____% sand-silt _____% clasts > 2 mm
Depth of observed groundwater table (cm) _____

* Sampling interval from surface	□ 0-10 cm (**1**)	Geochem	Sieved? < _____	microns
For heavy minerals:	□ 0-10 cm (**2**)	Heavy Min	Sieved? < _____	microns
	□ 90-100 cm (**3**)	Geochem	Sieved? < _____	microns
	□ 90-100 cm (**4**)	Heavy Min	Sieved? < _____	microns
	□ other, specify: ( )	_____	Sieved? < _____	microns

Possible sources of contamination, specify _____

OTHER

Field pH	Top	____	Munsell Colour - Dry	Top	_____
	Bottom	____		Bottom	_____
Texture	Top	_____	- Moist	Top	_____
	Bottom	_____		Bottom	_____

NUMBER OF SAMPLE BAGS **PHOTOS**

COMMENTS

Modified from Salminen, R. et al,. 1998. FOREGS geochemical mapping field manual. Geologian tutkimuskeskus, Opas 47, Geological Survey of Finland, Guide 47. Espoo. Appendix.

10 APPENDIX 3. QUALITY ASSESSMENT/QUALITY CONTROL

Appendix 3.1. Time series (groundwater)

Average and Relative Standard Deviation (RSD) shown in green below data.
(Relative Standard Deviation = 100 % x Standard Deviation / Average)
Numbers in red were reported as <LLD and are set to 0.5 LLD (Lower Limit of Detection)

SampleID	SampleID_long	Name	Property	Date
Unit				
G011	2004851011	Yardea Home Bore	Yardea	3/11/2004
201	2005851201	Yardea Home Bore	Yardea	29/04/2005

Field

	Temperature	Conductivity	pH	Eh	Dissoved oxygen
	degree Celsius	uS/cm		mV (SHE)	mg/L
G011	21.7	6960	6.96	N/A	N/A
201	21.3	7130	6.99	262.5	4.93
Average	21.5	7045	6.98		
RSD	1%	2%	0%		

ICP-ES & IC

	Al AES	B	Ba	Br	Ca	Cl	Cu AES	F	Fe AES	K	Li AES	Mg	Mn AES	Na	NO3
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
G011	0.05	1.17	0.26	7.0	293	2084	0.005	1.3	0.101	15	0.05	156	0.003	918	27
201	0.05	0.93	0.18	8.1	293	2076	0.05	1.4	0.005	23	0.05	162	0.002	851	27
Average	0.05	1.05	0.22	7.6	293	2080	0.028	1.4	0.053	19	0.05	159	0.003	884	27
RSD	0%	16%	25%	11%	0%	0%	116%	8%	128%	31%	0%	3%	37%	5%	0%

ICP-MS

	Ag	Al	As	B MS	Ba MS	Be	Bi	Cd	Ce	Co	Cr	Cs	Cu	Dy	Er
	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
G011	0.5	0.5	0.5	790	179	0.5	0.5	0.5	0.5	0.5	0.5	0.5	24	0.5	0.5
201	0.5	1.4	0.5	641	219	0.5	0.5	0.5	0.5	0.5	0.5	0.5	33	0.5	0.5
Average	0.5	1.0	0.5	716	199	0.5	0.5	0.5	0.5	0.5	0.5	0.5	28	0.5	0.5
RSD	0%	69%	0%	15%	14%	0%	0%	0%	0%	0%	0%	0%	22%	0%	0%

Carbon sachet

	Au	Pt	Pd	Bi	Mo	W	Ag	Cu	Ni
	ppt	ppt	ppt	ppt	ppb	ppb	ppb	ppb	ppb
G011	0.6	0.6	0.6	0.6	1.1	0.1	14.6	1.3	0.6
201	0.6	0.6	0.6	0.6	1.4	0.2	16.2	1.2	0.2
Average	0.6	0.6	0.6	0.6	1.2	0.1	15.4	1.3	0.4
RSD	0%	0%	0%	0%	18%	38%	7%	4%	58%

Note: Values <LLD have been halved (= 0.5 LLD)

SampleID
Unit
G011
201

Field

G011
201
Average
RSD

ICP-ES & IC

	PO4	Si	SiO2	SO4	Sr AES	Zn AES
	ppm	ppm	ppm	ppm	ppm	ppm
G011	N/A	47	100	217	2.7	0.020
201	0.1	41	87	230	3.1	0.019
Average		44	94	223	2.9	0.020
RSD		10%	10%	4%	10%	4%

ICP-MS

	Eu	Fe MS	Ga	Gd	Ge	Hf	Ho	La	Li	Lu	Mn MS	Mo	Nb	Nd	Ni	Pb	Pr	Rb	Sb	Sc	Sm	Sn	Sr MS	Ta	Tb
	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
G011	0.5	131	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	3101	0.5	0.5
201	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	3	0.5	2	0.5	0.5	0.5	0.5	0.5	0.5	5	0.5	13	0.5	0.5	3821	0.5	0.5
Average	0.5	66	0.5	0.5	0.5	0.5	0.5	0.5	2	0.5	1	0.5	0.5	0.5	0.5	0.5	0.5	3	0.5	7	0.5	0.5	3461	0.5	0.5
RSD	0%	140%	0%	0%	0%	0%	0%	0%	95%	0%	81%	0%	0%	0%	0%	0%	0%	116%	0%	131%	0%	0%	15%	0%	0%

Carbon sachet

G011
201
Average
RSD

SampleID
Unit
G011
201

Field

G011
201
Average
RSD

ICP-ES & IC

G011
201
Average
RSD

ICP-MS

	Th	U	V	W	Y MS	Yb	Zn	Zr
	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
G011	0.5	0.5	0.5	0.5	0.5	0.5	46	0.5
201	0.5	0.5	0.5	0.5	0.5	0.5	23	0.5
Average	0.5	0.5	0.5	0.5	0.5	0.5	34	0.5
RSD	0%	0%	0%	0%	0%	0%	47%	0%

Carbon sachet

G011
201
Average
RSD

Appendix 3.2. Blind replicates

Appendix 3.2.1. XRF analysis for multiple elements (regolith)

Average and Relative Standard Deviation (RSD) shown in green below data.
(Relative Standard Deviation = 100 % x Standard Deviation / Average)
Numbers in red were reported as <LLD and are set to 0.5 LLD (Lower Limit of Detection)

Sample	SampleID	Al2O3 XRF	Ba XRF	CaO XRF	Cl XRF	Cr XRF	Cu XRF	Fe2O3T XRF	K2O XRF	MgO XRF	MLOI Calculate	MnO XRF
		%	ppm	%	ppm	ppm	ppm	%	%	%	%	%
20058511011A	20058511011A	5.299	176	12.522	22	1	5	2.006	0.779	0.76	18.78	0.025
Replicate	20058511371	5.204	168	12.347	69	1	2	1.938	0.757	0.758	18.947	0.021
Average		5.2515	172	12.4345	45.5	1	3.5	1.972	0.768	0.759	18.8635	0.023
RSD		1%	3%	1%	73%	0%	61%	2%	2%	0%	1%	12%
20058511012B	20058511012B	2.151	56	44.265	2.5	1	0.5	0.874	0.348	0.994	40.558	0.007
Replicate	20058511372	2.188	119	44.475	2.5	1	6	0.876	0.35	1.011	40.214	0.008
Average		2.1695	87.5	44.37	2.5	1	3.25	0.875	0.349	1.0025	40.386	0.0075
RSD		1%	51%	0%	0%	0%	120%	0%	0%	1%	1%	9%
20058511081B	20058511081B	13.816	443	0.489	2.5	7	14	5.333	2.333	0.867	9.227	0.066
Replicate	20058511381	13.667	396	0.486	2.5	19	14	5.273	2.317	0.85	9.576	0.065
Average		13.7415	419.5	0.4875	2.5	13	14	5.303	2.325	0.8585	9.4015	0.0655
RSD		1%	8%	0%	0%	65%	0%	1%	0%	1%	3%	1%
20058511082A	20058511082A	5.941	284	10.776	954	1	9	2.205	1.118	1.147	15.784	0.014
Replicate	20058511382	5.994	257	10.907	990	1	7	2.224	1.128	1.161	14.888	0.014
Average		5.9675	270.5	10.8415	972	1	8	2.2145	1.123	1.154	15.336	0.014
RSD		1%	7%	1%	3%	0%	18%	1%	1%	1%	4%	0%
20058511161A	20058511161A	1.888	76	0.101	16	1	0.5	0.788	0.159	0.144	3.265	0.007
Replicate	20058511391	1.856	87	0.104	2.5	1	0.5	0.783	0.152	0.133	2.6	0.007
Average		1.872	81.5	0.1025	9.25	1	0.5	0.7855	0.1555	0.1385	2.9325	0.007
RSD		1%	10%	2%	103%	0%	0%	0%	3%	6%	16%	0%
20058511192B	20058511192B	10.654	271	17.766	2.5	2	32	3.979	1.132	1.242	25.487	0.029
Replicate	20058511402	10.66	243	17.842	2.5	8	23	4.012	1.138	1.257	24.862	0.029
Average		10.657	257	17.804	2.5	5	27.5	3.9955	1.135	1.2495	25.1745	0.029
RSD		0%	8%	0%	0%	85%	23%	1%	0%	1%	2%	0%
20058511241B	20058511241B	14.144	352	0.506	2.5	28	18	5.576	2.114	1.102	10.612	0.067
Replicate	20058511411	14.096	347	0.505	2.5	21	16	5.576	2.106	1.093	11.168	0.067
Average		14.12	349.5	0.5055	2.5	24.5	17	5.576	2.11	1.0975	10.89	0.067
RSD		0%	1%	0%	0%	20%	8%	0%	0%	1%	4%	0%
20058511242A	20058511242A	9.857	275	0.379	8	1	13	3.828	1.39	0.852	7.73	0.031
Replicate	20058511412	10.224	234	0.403	8	11	16	4.011	1.438	0.9	8.403	0.032
Average		10.0405	254.5	0.391	8	6	14.5	3.9195	1.414	0.876	8.0665	0.0315
RSD		3%	11%	4%	0%	118%	15%	3%	2%	4%	6%	2%

Sample	SampleID	Al2O3 XRF	Ba XRF	CaO XRF	Cl XRF	Cr XRF	Cu XRF	Fe2O3T XRF	K2O XRF	MgO XRF	MLOI Calculate	MnO XRF
		%	ppm	%	ppm	ppm	ppm	%	%	%	%	%
20058511321A	20058511321A	13.476	276	0.314	2.5	17	16	5.459	1.423	0.628	9.549	0.049
Replicate	20058511421	13.419	290	0.316	2.5	16	31	5.439	1.418	0.627	9.776	0.048
Average		13.4475	283	0.315	2.5	16.5	23.5	5.449	1.4205	0.6275	9.6625	0.0485
RSD		0%	3%	0%	0%	4%	45%	0%	0%	0%	2%	1%
20058511322B	20058511322B	19.814	379	0.629	2.5	31	21	7.314	1.738	1.056	16.597	0.048
Replicate	20058511422	19.848	385	0.634	50	35	22	7.341	1.745	1.062	16.272	0.049
Average		19.831	382	0.6315	26.25	33	21.5	7.3275	1.7415	1.059	16.4345	0.0485
RSD		0%	1%	1%	128%	9%	3%	0%	0%	0%	1%	1%
20058511361B	20058511361B	9.698	571	4.363	8136	2	14	3.71	1.822	2.11	12.124	0.044
Replicate	20058511431	9.656	576	4.324	7762	1	9	3.662	1.81	2.089	12.592	0.042
Average		9.677	573.5	4.3435	7949	1.5	11.5	3.686	1.816	2.0995	12.358	0.043
RSD		0%	1%	1%	3%	47%	31%	1%	0%	1%	3%	3%
20058511362A	20058511362A	9.032	512	2.6	7609	1	13	3.308	1.654	1.839	12.947	0.032
Replicate	20058511432	8.851	473	2.542	7343	1	13	3.266	1.633	1.804	11.38	0.031
Average		8.9415	492.5	2.571	7476	1	13	3.287	1.6435	1.8215	12.1635	0.0315
RSD		1%	6%	2%	3%	0%	0%	1%	1%	1%	9%	2%
Min RSD		**0%**	**1%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**1%**	**0%**
Ave RSD		**1%**	**9%**	**1%**	**26%**	**29%**	**27%**	**1%**	**1%**	**1%**	**4%**	**3%**
Max RSD		**3%**	**51%**	**4%**	**128%**	**118%**	**120%**	**3%**	**3%**	**6%**	**16%**	**12%**

Note: Values <LLD have been halved (= 0.5 LLD)

A: <180 um
B: <75 um

Sample	SampleID	Na2O XRF %	Ni XRF ppm	P2O5 XRF %	Rb XRF ppm	Sc XRF ppm	SiO2 XRF %	SO3 XRF %	Sr XRF ppm	TiO2 XRF %	V XRF ppm	Zn XRF ppm	Zr XRF ppm
20058511011A	20058511011A	0.113	10	0.059	36	1	59.202	0.052	263	0.324	22	16	257
Replicate	20058511371	0.094	4	0.06	35	1	59.428	0.052	256	0.314	19	14	251
Average		0.1035	7	0.0595	35.5	1	59.315	0.052	259.5	0.319	20.5	15	254
RSD		13%	61%	1%	2%	0%	0%	0%	2%	2%	10%	9%	2%
20058511012B	20058511012B	0.099	3	0.016	15	1	10.345	0.059	840	0.172	19	2	227
Replicate	20058511372	0.105	3	0.017	19	1	10.404	0.057	847	0.173	22	0.5	249
Average		0.102	3	0.0165	17	1	10.3745	0.058	843.5	0.1725	20.5	1.25	238
RSD		4%	0%	4%	17%	0%	0%	2%	1%	0%	10%	85%	7%
20058511081B	20058511081B	0.342	18	0.099	99	8	66.213	0.039	97	0.998	68	68	961
Replicate	20058511381	0.342	14	0.096	96	7	66.125	0.04	97	0.992	65	67	955
Average		0.342	16	0.0975	97.5	7.5	66.169	0.0395	97	0.995	66.5	67.5	958
RSD		0%	18%	2%	2%	9%	0%	2%	0%	0%	3%	1%	0%
20058511082A	20058511082A	0.382	4	0.046	42	1	61.989	0.044	222	0.36	23	17	405
Replicate	20058511382	0.38	13	0.048	45	1	62.66	0.044	228	0.359	28	20	364
Average		0.381	8.5	0.047	43.5	1	62.3245	0.044	225	0.3595	25.5	18.5	384.5
RSD		0%	75%	3%	5%	0%	1%	0%	2%	0%	14%	11%	8%
20058511161A	20058511161A	0.024	1	0.015	7	1	93.37	0.012	10	0.19	1.5	2	311
Replicate	20058511391	0.019	8	0.014	9	1	94.109	0.011	9	0.187	1.5	0.5	228
Average		0.0215	4.5	0.0145	8	1	93.7395	0.0115	9.5	0.1885	1.5	1.25	269.5
RSD		16%	110%	5%	18%	0%	1%	6%	7%	1%	0%	85%	22%
20058511192B	20058511192B	0.152	26	0.065	66	1	38.594	0.066	300	0.686	67	41	697
Replicate	20058511402	0.155	26	0.064	69	3	39.075	0.065	299	0.693	70	40	721
Average		0.1535	26	0.0645	67.5	2	38.8345	0.0655	299.5	0.6895	68.5	40.5	709
RSD		1%	0%	1%	3%	71%	1%	1%	0%	1%	3%	2%	2%
20058511241B	20058511241B	0.237	31	0.094	82	7	64.321	0.033	89	1.015	69	64	1064
Replicate	20058511411	0.236	21	0.095	84	7	63.834	0.034	87	1.015	70	64	1046
Average		0.2365	26	0.0945	83	7	64.0775	0.0335	88	1.015	69.5	64	1055
RSD		0%	27%	1%	2%	0%	1%	2%	2%	0%	1%	0%	1%
20058511242A	20058511242A	0.154	15	0.052	59	2	75.025	0.02	56	0.591	46	40	415
Replicate	20058511412	0.154	19	0.053	59	2	73.647	0.02	59	0.618	46	38	476
Average		0.154	17	0.0525	59	2	74.336	0.02	57.5	0.6045	46	39	445.5
RSD		0%	17%	1%	0%	0%	1%	0%	4%	3%	0%	4%	10%

Sample	SampleID	Na2O XRF %	Ni XRF ppm	P2O5 XRF %	Rb XRF ppm	Sc XRF ppm	SiO2 XRF %	SO3 XRF %	Sr XRF ppm	TiO2 XRF %	V XRF ppm	Zn XRF ppm	Zr XRF ppm
20058511321A	20058511321A	0.178	14	0.11	65	8	67.948	0.032	71	0.739	84	63	374
Replicate	20058511421	0.177	23	0.11	65	7	67.792	0.033	70	0.744	85	63	378
Average		0.1775	18.5	0.11	65	7.5	67.87	0.0325	70.5	0.7415	84.5	63	376
RSD		0%	34%	0%	0%	9%	0%	2%	1%	0%	1%	0%	1%
20058511322B	20058511322B	0.172	27	0.07	96	8	51.52	0.029	99	0.899	108	64	357
Replicate	20058511422	0.181	26	0.071	94	11	51.741	0.029	99	0.901	113	65	366
Average		0.1765	26.5	0.0705	95	9.5	51.6305	0.029	99	0.9	110.5	64.5	361.5
RSD		4%	3%	1%	1%	22%	0%	0%	0%	0%	3%	1%	2%
20058511361B	20058511361B	0.929	12	0.08	66	7	63.391	0.06	131	0.7	59	37	670
Replicate	20058511431	0.907	14	0.079	64	5	63.16	0.06	130	0.689	57	37	661
Average		0.918	13	0.0795	65	6	63.2755	0.06	130.5	0.6945	58	37	665.5
RSD		2%	11%	1%	2%	24%	0%	0%	1%	1%	2%	0%	1%
20058511362A	20058511362A	1.057	9	0.064	61	1	66.01	0.094	101	0.493	51	31	339
Replicate	20058511432	1.024	10	0.063	59	4	67.988	0.093	102	0.486	54	31	314
Average		1.0405	9.5	0.0635	60	2.5	66.999	0.0935	101.5	0.4895	52.5	31	326.5
RSD		2%	7%	1%	2%	85%	2%	1%	1%	1%	4%	0%	5%
Min RSD		**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**
Ave RSD		**4%**	**30%**	**2%**	**5%**	**18%**	**1%**	**1%**	**2%**	**1%**	**4%**	**17%**	**5%**
Max RSD		**16%**	**110%**	**5%**	**18%**	**85%**	**2%**	**6%**	**7%**	**3%**	**14%**	**85%**	**22%**

Note: Values <LLD have been halv

A: <180 um
B: <75 um

Appendix 3.2.2. ICP-MS analysis for multiple elements (regolith)

Average (Ave) and Relative Standard Deviation (RSD) shown in green below data.
(Relative Standard Deviation = 100 % x Standard Deviation / Average)
Numbers in red were reported as <LLD and are set to 0.5 LLD (Lower Limit of Detection)

Sample	SampleID	Ag	Al	As	Au	Ba	Be	Bi	Ca	Cd	Ce	Co	Cr	Cs	Cu	Dy	Er	Eu
		ppb	%	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
101-1-180um	101-1-180um	10	2.92	2	0.05	154	1	0.02	9.51	0.08	28.55	3.2	24	1.7	11.17	1.8	1	0.5
101-1-180um_replicate	137-1-180um	13892	2.89	2.2	0.05	162	0.5	0.13	9.18	0.07	25.26	3.5	30	1.8	10.34	2	1	0.5
Ave		6951	2.905	2.1	0.05	158	0.75	0.075	9.345	0.075	26.905	3.35	27	1.75	10.755	1.9	1	0.5
RSD		141%	1%	7%	0%	4%	47%	104%	2%	9%	9%	6%	16%	4%	5%	7%	0%	0%
116-1-180um	116-1-180um	10	1.09	1	0.05	66	0.5	0.02	0.08	0.01	12	1.9	9	0.7	3.28	0.7	0.3	0.2
116-1-180um_replicate	139-1-180um	26	1.14	1.5	0.05	71	0.5	0.14	0.08	0.04	13.95	1.7	13	0.8	3.48	0.8	0.4	0.2
Ave		18	1.115	1.25	0.05	68.5	0.5	0.08	0.08	0.025	12.975	1.8	11	0.75	3.38	0.75	0.35	0.2
RSD		63%	3%	28%	0%	5%	0%	106%	0%	85%	11%	8%	26%	9%	4%	9%	20%	0%
132-1-180um	132-1-180um	26	7.26	6.5	0.05	278	2	0.16	0.24	0.15	48.42	10.5	52	3.9	24.13	3.2	2.1	1
132-1-180um_replicate	142-1-180um	37	6.82	6.9	0.05	292	2	0.3	0.21	0.13	67.79	10.3	55	4.5	24.83	3.8	2.1	1.2
Ave		31.5	7.04	6.7	0.05	285	2	0.23	0.225	0.14	58.105	10.4	53.5	4.2	24.48	3.5	2.1	1.1
RSD		25%	4%	4%	0%	3%	0%	43%	9%	10%	24%	1%	4%	10%	2%	12%	0%	13%
108-2-180um	108-2-180um	40	3.31	1.3	0.05	270	1	0.13	8.35	0.05	27.98	3.7	22	1.8	13.08	1.9	1.2	0.5
108-2-180um_replicate	138-2-180um	28	3.12	2.9	0.05	260	1	0.15	7.86	0.05	32.38	2.9	15	1.8	13.08	1.9	1	0.5
Ave		34	3.215	2.1	0.05	265	1	0.14	8.105	0.05	30.18	3.3	18.5	1.8	13.08	1.9	1.1	0.5
RSD		25%	4%	54%	0%	3%	0%	10%	4%	0%	10%	17%	27%	0%	0%	0%	13%	0%
124-2-180um	124-2-180um	32	5.64	3	0.05	242	1	0.22	0.31	0.05	42.96	7.5	45	3.1	17.57	2.2	1.4	0.7
124-2-180um_replicate	141-2-180um	10	5.44	3.2	0.05	243	1	0.23	0.33	0.07	42.97	7.2	42	3.2	17.99	2.2	1.2	0.7
Ave		21	5.54	3.1	0.05	242.5	1	0.225	0.32	0.06	42.965	7.35	43.5	3.15	17.78	2.2	1.3	0.7
RSD		74%	3%	5%	0%	0%	0%	3%	4%	24%	0%	3%	5%	2%	2%	0%	11%	0%
136-2-180um	136-2-180um	22	4.75	5	0.05	492	1	0.18	1.95	0.08	44.56	6.5	30	3.2	16.51	2.6	1.4	0.7
136-2-180um_replicate	143-2-180um	10	4.85	5.3	0.05	506	1	0.21	2.02	0.07	44.34	6.7	31	3.1	17	2.7	1.5	0.7
Ave		16	4.8	5.15	0.05	499	1	0.195	1.985	0.075	44.45	6.6	30.5	3.15	16.755	2.65	1.45	0.7
RSD		53%	1%	4%	0%	2%	0%	11%	2%	9%	0%	2%	2%	2%	2%	3%	5%	0%
108-1-75um	108-1-75um	51	6.76	5.2	0.05	405	2	0.25	0.35	0.18	74.66	9.2	56	4.1	18.64	4.4	2.2	1.3
108-1-75um_replicate	138-1-75um	36	7.52	5	0.05	437	2	0.28	0.39	0.23	79.71	10.4	57	4.3	19.06	3.9	2.3	1.3
Ave		43.5	7.14	5.1	0.05	421	2	0.265	0.37	0.205	77.185	9.8	56.5	4.2	18.85	4.15	2.25	1.3
RSD		24%	8%	3%	0%	5%	0%	8%	8%	17%	5%	9%	1%	3%	2%	9%	3%	0%
124-1-75um	124-1-75um	10	7.82	4.3	0.05	364	2	0.3	0.39	0.17	70.24	13.5	70	4.6	26.81	3.5	1.9	1
124-1-75um_replicate	141-1-75um	10	7.31	4.7	0.05	367	3	0.29	0.37	0.13	67.82	12.7	61	4.5	24.95	3.5	1.9	1.1
Ave		10	7.565	4.5	0.05	365.5	2.5	0.295	0.38	0.15	69.03	13.1	65.5	4.55	25.88	3.5	1.9	1.05
RSD		0%	5%	6%	0%	1%	28%	2%	4%	19%	2%	4%	10%	2%	5%	0%	0%	7%
136-1-75um	136-1-75um	10	5.32	5.5	0.05	628	1	0.22	3.43	0.07	49.41	7.6	40	3.3	17.81	3	1.7	0.8
136-1-75um_replicate	143-1-75um	10	5.44	5.2	0.05	628	1	0.22	3.52	0.08	50.34	7.7	40	3.5	17.82	3	1.6	0.8

Sample	SampleID	Ag ppb	Al %	As ppm	Au ppm	Ba ppm	Be ppm	Bi ppm	Ca %	Cd ppm	Ce ppm	Co ppm	Cr ppm	Cs ppm	Cu ppm	Dy ppm	Er ppm	Eu ppm
Ave		10	5.38	5.35	0.05	628	1	0.22	3.475	0.075	49.875	7.65	40	3.4	17.815	3	1.65	0.8
RSD		0%	2%	4%	0%	0%	0%	0%	2%	9%	1%	1%	0%	4%	0%	0%	4%	0%
101-2-75um	101-2-75um	36	1.16	2.8	0.05	87	1	0.02	31.43	0.06	14.64	2.7	14	0.8	6.98	1.1	0.6	0.3
101-2-75um_replicate	137-2-75um	25	1.28	3.8	0.05	91	0.5	0.04	33.5	0.05	15.56	2.9	16	0.8	7.47	1.1	0.5	0.2
Ave		30.5	1.22	3.3	0.05	89	0.75	0.03	32.465	0.055	15.1	2.8	15	0.8	7.225	1.1	0.55	0.25
RSD		26%	7%	21%	0%	3%	47%	47%	5%	13%	4%	5%	9%	0%	5%	0%	13%	28%
119-2-75um	119-2-75um	70	6.36	9	0.05	291	1	0.23	14.11	0.23	56.16	12.4	48	4.2	29.32	4.4	2.3	1.3
119-2-75um_replicate	140-2-75um	70	6.27	7.9	0.05	281	2	0.21	14.09	0.21	50.59	12.4	49	4	29.48	4	2.1	1.1
Ave		70	6.315	8.45	0.05	286	1.5	0.22	14.1	0.22	53.375	12.4	48.5	4.1	29.4	4.2	2.2	1.2
RSD		0%	1%	9%	0%	2%	47%	6%	0%	6%	7%	0%	1%	3%	0%	7%	6%	12%
132-2-75um	132-2-75um	55	10.62	8	0.05	334	3	0.32	0.39	0.15	44.42	13.1	62	5.5	30.75	3.8	2.2	1
132-2-75um_replicate	142-2-75um	44	10.12	8.4	0.05	317	2	0.29	0.38	0.12	42.42	12.9	61	5.3	29.1	3.8	2	1
Ave		49.5	10.37	8.2	0.05	325.5	2.5	0.305	0.385	0.135	43.42	13	61.5	5.4	29.925	3.8	2.1	1
RSD		16%	3%	3%	0%	4%	28%	7%	2%	16%	3%	1%	1%	3%	4%	0%	7%	0%
Min RSD		**0%**	**1%**	**3%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**
Ave RSD		**37%**	**3%**	**12%**	**0%**	**3%**	**16%**	**29%**	**4%**	**18%**	**6%**	**5%**	**9%**	**4%**	**3%**	**4%**	**7%**	**5%**
Max RSD		**141%**	**8%**	**54%**	**0%**	**5%**	**47%**	**106%**	**9%**	**85%**	**24%**	**17%**	**27%**	**10%**	**5%**	**12%**	**20%**	**28%**

Sample	Fe	Ga	Gd	Hf	Ho	K	La	Li	Lu	Mg	Mn	Mo	Na	Nb	Nd	Ni	P	Pb
	%	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	%	ppm	ppm	%	ppm	ppm	ppm	%	ppm
101-1-180um	1.51	7.52	2.2	1.25	0.3	0.63	12.9	17.8	0.2	0.43	194	0.35	0.086	3.78	13.1	10.2	0.03	8.48
101-1-180um_replicate	1.49	7.05	2.1	1.32	0.4	0.69	11.2	16.5	0.1	0.44	190	0.31	0.083	3.72	12.2	10.6	0.03	8.41
Ave	1.5	7.285	2.15	1.285	0.35	0.66	12.05	17.15	0.15	0.435	192	0.33	0.0845	3.75	12.65	10.4	0.03	8.445
RSD	1%	5%	3%	4%	20%	6%	10%	5%	47%	2%	1%	9%	3%	1%	5%	3%	0%	1%
116-1-180um	0.65	3.13	0.7	0.84	0.1	0.14	5.4	8.6	0.1	0.1	48	0.17	0.017	2.67	5	3.6	0.004	4.77
116-1-180um_replicate	0.67	3.03	0.8	1.05	0.1	0.17	5.7	8.5	0.1	0.11	50	0.2	0.018	2.9	6.1	4.2	0.005	5.12
Ave	0.66	3.08	0.75	0.945	0.1	0.155	5.55	8.55	0.1	0.105	49	0.185	0.0175	2.785	5.55	3.9	0.0045	4.945
RSD	2%	2%	9%	16%	0%	14%	4%	1%	0%	7%	3%	11%	4%	6%	14%	11%	16%	5%
132-1-180um	4.05	17.82	3.4	3.12	0.6	1.11	23	36.4	0.3	0.37	391	0.79	0.134	8.43	22.3	21.9	0.051	19.56
132-1-180um_replicate	4.11	17.08	4.5	2.99	0.7	1.18	30.5	34	0.3	0.36	389	0.85	0.127	7.84	27.5	21.4	0.052	19.15
Ave	4.08	17.45	3.95	3.055	0.65	1.145	26.75	35.2	0.3	0.365	390	0.82	0.1305	8.135	24.9	21.65	0.0515	19.355
RSD	1%	3%	20%	3%	11%	4%	20%	5%	0%	2%	0%	5%	4%	5%	15%	2%	1%	1%
108-2-180um	1.7	8.07	2.2	2.22	0.4	0.98	12.9	14	0.1	0.67	106	0.27	0.287	4.51	13	9.9	0.024	8.52
108-2-180um_replicate	1.62	8.15	2.1	2.03	0.4	0.88	14.6	14.1	0.2	0.63	102	0.32	0.283	4.69	13.4	10	0.023	7.79
Ave	1.66	8.11	2.15	2.125	0.4	0.93	13.75	14.05	0.15	0.65	104	0.295	0.285	4.6	13.2	9.95	0.0235	8.155
RSD	3%	1%	3%	6%	0%	8%	9%	1%	47%	4%	3%	12%	1%	3%	2%	1%	3%	6%
124-2-180um	3.04	12.83	2.6	2.43	0.5	1.18	20.9	22.4	0.2	0.52	251	0.48	0.108	6.24	17.3	19.7	0.024	14.58
124-2-180um_replicate	3	14.3	2.7	2.12	0.4	1.14	20.4	26.3	0.2	0.53	252	0.54	0.109	7.27	18.3	20.8	0.023	15.22
Ave	3.02	13.565	2.65	2.275	0.45	1.16	20.65	24.35	0.2	0.525	251.5	0.51	0.1085	6.755	17.8	20.25	0.0235	14.9
RSD	1%	8%	3%	10%	16%	2%	2%	11%	0%	1%	0%	8%	1%	11%	4%	4%	3%	3%
136-2-180um	2.38	12.46	3	2.76	0.5	1.27	19.8	20	0.2	1.03	239	0.6	0.783	6.48	18.2	13.1	0.03	13.79
136-2-180um_replicate	2.54	13.51	3	2.64	0.6	1.32	20.6	20.3	0.2	1.07	252	0.61	0.825	6.59	17.1	13.6	0.03	14.05
Ave	2.46	12.985	3	2.7	0.55	1.295	20.2	20.15	0.2	1.05	245.5	0.605	0.804	6.535	17.65	13.35	0.03	13.92
RSD	5%	6%	0%	3%	13%	3%	3%	1%	0%	3%	4%	1%	4%	1%	4%	3%	0%	1%
108-1-75um	3.93	19.31	4.2	4.64	0.9	1.68	32.4	34.1	0.3	0.44	535	0.68	0.239	11.78	30.8	21	0.042	19.57
108-1-75um_replicate	4.16	20.17	5.3	4.65	0.9	1.77	36.6	36.3	0.4	0.48	556	0.75	0.259	11.99	32.2	21.3	0.049	21.62
Ave	4.045	19.74	4.75	4.645	0.9	1.725	34.5	35.2	0.35	0.46	545.5	0.715	0.249	11.885	31.5	21.15	0.0455	20.595
RSD	4%	3%	16%	0%	0%	4%	9%	4%	20%	6%	3%	7%	6%	1%	3%	1%	11%	7%
124-1-75um	4.25	20.7	4	3.36	0.7	1.69	32.7	40	0.3	0.66	555	0.92	0.187	11.43	29	26.9	0.047	22.53
124-1-75um_replicate	4.31	20.29	4.1	3.46	0.7	1.57	31.3	36.4	0.3	0.6	547	0.84	0.179	11.16	26	26	0.044	22.41
Ave	4.28	20.495	4.05	3.41	0.7	1.63	32	38.2	0.3	0.63	551	0.88	0.183	11.295	27.5	26.45	0.0455	22.47
RSD	1%	1%	2%	2%	0%	5%	3%	7%	0%	7%	1%	6%	3%	2%	8%	2%	5%	0%
136-1-75um	2.79	14.05	3	2.74	0.6	1.36	22.5	27.4	0.3	1.15	334	0.61	0.692	8.52	19.7	15.4	0.04	16.02
136-1-75um_replicate	2.91	13.19	3.2	3.13	0.6	1.39	23.3	29.2	0.3	1.18	350	0.69	0.706	8.82	20.6	16.1	0.04	16.25

Sample	Fe	Ga	Gd	Hf	Ho	K	La	Li	Lu	Mg	Mn	Mo	Na	Nb	Nd	Ni	P	Pb
	%	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	%	ppm	ppm	%	ppm	ppm	ppm	%	ppm
Ave	2.85	13.62	3.1	2.935	0.6	1.375	22.9	28.3	0.3	1.165	342	0.65	0.699	8.67	20.15	15.75	0.04	16.135
RSD	3%	4%	5%	9%	0%	2%	2%	4%	0%	2%	3%	9%	1%	2%	3%	3%	0%	1%
101-2-75um	0.6	3.01	1.2	0.56	0.2	0.27	6.6	7.4	0.1	0.53	48	0.16	0.068	2.05	6.4	8.4	0.01	3.08
101-2-75um_replicate	0.64	3.63	1.2	0.68	0.2	0.28	7.3	7.9	0.1	0.53	48	0.14	0.071	2.04	8.1	8.2	0.01	3.41
Ave	0.62	3.32	1.2	0.62	0.2	0.275	6.95	7.65	0.1	0.53	48	0.15	0.0695	2.045	7.25	8.3	0.01	3.245
RSD	5%	13%	0%	14%	0%	3%	7%	5%	0%	0%	0%	9%	3%	0%	17%	2%	0%	7%
119-2-75um	3.14	17.07	5	3.28	0.8	1	30.9	37.5	0.4	0.74	237	0.63	0.13	8.65	31.8	28.5	0.034	14.92
119-2-75um_replicate	3.06	16.31	4.5	2.92	0.8	0.99	27.5	34.4	0.3	0.73	230	0.63	0.123	10.44	28.6	28	0.032	15.34
Ave	3.1	16.69	4.75	3.1	0.8	0.995	29.2	35.95	0.35	0.735	233.5	0.63	0.1265	9.545	30.2	28.25	0.033	15.13
RSD	2%	3%	7%	8%	0%	1%	8%	6%	20%	1%	2%	0%	4%	13%	7%	1%	4%	2%
132-2-75um	5.49	28.58	4.5	3.99	0.7	1.3	20.7	57.2	0.3	0.56	373	0.85	0.122	10.3	24	32.1	0.031	22.41
132-2-75um_replicate	5.27	26.83	4.3	3.6	0.7	1.3	20.4	54.1	0.3	0.57	356	0.8	0.116	10.24	22	30.5	0.03	21
Ave	5.38	27.705	4.4	3.795	0.7	1.3	20.55	55.65	0.3	0.565	364.5	0.825	0.119	10.27	23	31.3	0.0305	21.705
RSD	3%	4%	3%	7%	0%	0%	1%	4%	0%	1%	3%	4%	4%	0%	6%	4%	2%	5%
Min RSD	**1%**	**1%**	**0%**	**0%**	**0%**	**0%**	**1%**	**1%**	**0%**	**0%**	**0%**	**0%**	**1%**	**0%**	**2%**	**1%**	**0%**	**0%**
Ave RSD	**3%**	**4%**	**6%**	**7%**	**5%**	**4%**	**6%**	**5%**	**11%**	**3%**	**2%**	**7%**	**3%**	**4%**	**7%**	**3%**	**4%**	**3%**
Max RSD	**5%**	**13%**	**20%**	**16%**	**20%**	**14%**	**20%**	**11%**	**47%**	**7%**	**4%**	**12%**	**6%**	**13%**	**17%**	**11%**	**16%**	**7%**

Sample	Pr	Rb	S	Sb	Sc	Sm	Sn	Sr	Ta	Tb	Th	Ti	Tm	U	V	W	Y	Yb	Zn
	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm
101-1-180um	3	34.8	0.02	0.15	5.1	2.4	1.9	294	0.4	0.3	4.8	0.187	0.1	0.5	35	0.5	9.9	0.9	26.1
101-1-180um_replicate	3.1	32.4	0.05	0.1	5.3	2.5	1.2	287	0.4	0.3	5.1	0.194	0.1	0.5	33	0.5	9.7	0.9	26
Ave	3.05	33.6	0.035	0.125	5.2	2.45	1.55	290.5	0.4	0.3	4.95	0.1905	0.1	0.5	34	0.5	9.8	0.9	26.05
RSD	2%	5%	61%	28%	3%	3%	32%	2%	0%	0%	4%	3%	0%	0%	4%	0%	1%	0%	0%
116-1-180um	1.3	12.9	0.02	0.04	1.8	0.9	0.4	16	0.2	0.1	2.1	0.139	0.05	0.2	13	0.2	3.3	0.4	8.2
116-1-180um_replicate	1.5	13.2	0.02	0.05	2.3	1.1	3.6	17	0.3	0.1	2.2	0.139	0.05	0.2	14	0.5	3.5	0.4	8.1
Ave	1.4	13.05	0.02	0.045	2.05	1	2	16.5	0.25	0.1	2.15	0.139	0.05	0.2	13.5	0.35	3.4	0.4	8.15
RSD	10%	2%	0%	16%	17%	14%	113%	4%	28%	0%	3%	0%	0%	0%	5%	61%	4%	0%	1%
132-1-180um	5.3	60.3	0.02	0.38	11.5	4.3	2	85	0.8	0.5	10.8	0.419	0.2	1.1	101	0.9	17	1.8	77.9
132-1-180um_replicate	7.6	68.5	0.02	0.37	13.4	5.8	4.1	93	0.8	0.7	13.5	0.465	0.3	1.1	106	1.1	20.8	2	80.1
Ave	6.45	64.4	0.02	0.375	12.45	5.05	3.05	89	0.8	0.6	12.15	0.442	0.25	1.1	103.5	1	18.9	1.9	79
RSD	25%	9%	0%	2%	11%	21%	49%	6%	0%	24%	16%	7%	28%	0%	3%	14%	14%	7%	2%
108-2-180um	3.4	42	0.04	0.1	4.8	2.6	1.2	242	0.5	0.3	5.5	0.214	0.2	1.3	34	0.6	10.2	1.2	31.6
108-2-180um_replicate	3.3	44	0.04	0.21	5.2	2.8	1.1	222	0.5	0.3	6.2	0.207	0.2	1.3	39	0.4	10.6	1.2	28.1
Ave	3.35	43	0.04	0.155	5	2.7	1.15	232	0.5	0.3	5.85	0.2105	0.2	1.3	36.5	0.5	10.4	1.2	29.85
RSD	2%	3%	0%	50%	6%	5%	6%	6%	0%	0%	8%	2%	0%	0%	10%	28%	3%	0%	8%
124-2-180um	4.9	61	0.02	0.16	8.4	3.4	1.9	68	0.7	0.4	9	0.404	0.2	0.8	58	0.8	13.1	1.3	55.2
124-2-180um_replicate	4.3	63.2	0.02	0.31	9.3	3.5	1.9	70	0.8	0.4	8.6	0.395	0.2	0.8	60	0.7	12.5	1.3	54.5
Ave	4.6	62.1	0.02	0.235	8.85	3.45	1.9	69	0.75	0.4	8.8	0.3995	0.2	0.8	59	0.75	12.8	1.3	54.85
RSD	9%	3%	0%	45%	7%	2%	0%	2%	9%	0%	3%	2%	0%	0%	2%	9%	3%	0%	1%
136-2-180um	4.4	60.1	0.09	0.33	7.5	3.3	1.8	115	0.7	0.4	8.6	0.291	0.2	1.9	68	0.8	13.3	1.5	42.8
136-2-180um_replicate	4.6	66.4	0.1	0.4	7.7	3.5	1.8	116	0.7	0.4	8.7	0.309	0.2	2	75	1	13.8	1.5	44.4
Ave	4.5	63.25	0.095	0.365	7.6	3.4	1.8	115.5	0.7	0.4	8.65	0.3	0.2	1.95	71.5	0.9	13.55	1.5	43.6
RSD	3%	7%	7%	14%	2%	4%	0%	1%	0%	0%	1%	4%	0%	4%	7%	16%	3%	0%	3%
108-1-75um	7.4	95.3	0.02	0.42	12	6.1	2.7	106	1.2	0.7	13.9	0.586	0.3	1.6	80	1	21.8	2.5	85.8
108-1-75um_replicate	8.2	95.7	0.02	0.41	12.3	5.7	2.6	115	1.2	0.8	16	0.542	0.4	1.7	85	1.1	22.9	2.4	87.2
Ave	7.8	95.5	0.02	0.415	12.15	5.9	2.65	110.5	1.2	0.75	14.95	0.564	0.35	1.65	82.5	1.05	22.35	2.45	86.5
RSD	7%	0%	0%	2%	2%	5%	3%	6%	0%	9%	10%	6%	20%	4%	4%	7%	3%	3%	1%
124-1-75um	7.1	86.7	0.02	0.38	13.2	5.2	2.6	109	1.2	0.7	15.4	0.574	0.3	1.4	87	1.1	19.6	2	82.8
124-1-75um_replicate	6.9	82.8	0.02	0.41	12.9	4.5	2.5	104	1.1	0.6	13.9	0.579	0.2	1.3	95	1	19.5	1.9	86
Ave	7	84.75	0.02	0.395	13.05	4.85	2.55	106.5	1.15	0.65	14.65	0.5765	0.25	1.35	91	1.05	19.55	1.95	84.4
RSD	2%	3%	0%	5%	2%	10%	3%	3%	6%	11%	7%	1%	28%	5%	6%	7%	0%	4%	3%
136-1-75um	5.4	64	0.05	0.33	8.6	4	1.7	151	0.9	0.5	11.5	0.378	0.2	1.6	67	0.9	14.6	1.6	52.6
136-1-75um_replicate	5.2	66.6	0.05	0.36	9	4.2	1.9	151	1	0.5	11.6	0.404	0.2	1.7	70	0.9	14.9	1.7	56.1

Sample	Pr	Rb	S	Sb	Sc	Sm	Sn	Sr	Ta	Tb	Th	Ti	Tm	U	V	W	Y	Yb	Zn
	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Ave	5.3	65.3	0.05	0.345	8.8	4.1	1.8	151	0.95	0.5	11.55	0.391	0.2	1.65	68.5	0.9	14.75	1.65	54.35
RSD	3%	3%	0%	6%	3%	3%	8%	0%	7%	0%	1%	5%	0%	4%	3%	0%	1%	4%	5%
101-2-75um	2	13.4	0.04	0.13	2.4	1.3	0.4	915	0.2	0.2	2.4	0.082	0.1	0.6	22	0.3	6.2	0.6	6.5
101-2-75um_replicate	2	16.4	0.04	0.12	2.7	1.5	0.4	919	0.2	0.2	2.7	0.088	0.1	0.6	24	0.3	7	0.7	8.8
Ave	2	14.9	0.04	0.125	2.55	1.4	0.4	917	0.2	0.2	2.55	0.085	0.1	0.6	23	0.3	6.6	0.65	7.65
RSD	0%	14%	0%	6%	8%	10%	0%	0%	0%	0%	8%	5%	0%	0%	6%	0%	9%	11%	21%
119-2-75um	7.3	76.9	0.07	0.36	9.6	6.1	2.1	341	0.8	0.8	10.8	0.407	0.3	1.4	87	1.1	23.3	2.4	57.8
119-2-75um_replicate	6.8	78.1	0.07	0.38	9.4	5.4	2.1	338	1	0.6	10.4	0.404	0.3	1.4	85	1.1	22.8	2.1	58.6
Ave	7.05	77.5	0.07	0.37	9.5	5.75	2.1	339.5	0.9	0.7	10.6	0.4055	0.3	1.4	86	1.1	23.05	2.25	58.2
RSD	5%	1%	0%	4%	1%	9%	0%	1%	16%	20%	3%	1%	0%	0%	2%	0%	2%	9%	1%
132-2-75um	5.7	88.3	0.02	0.49	14.1	4.9	2.9	99	1	0.7	11.3	0.566	0.3	1.6	133	1.5	19.5	2.3	77
132-2-75um_replicate	5.4	88.5	0.02	0.49	14.1	4.8	3	101	0.9	0.6	10.2	0.522	0.3	1.5	125	1.3	19.9	2.1	76.9
Ave	5.55	88.4	0.02	0.49	14.1	4.85	2.95	100	0.95	0.65	10.75	0.544	0.3	1.55	129	1.4	19.7	2.2	76.95
RSD	4%	0%	0%	0%	0%	1%	2%	1%	7%	11%	7%	6%	0%	5%	4%	10%	1%	6%	0%
Min RSD	**0%**	**0%**	**0%**	**0%**	**0%**	**1%**	**0%**	**0%**	**0%**	**0%**	**1%**	**0%**	**0%**	**0%**	**2%**	**0%**	**0%**	**0%**	**0%**
Ave RSD	**6%**	**4%**	**6%**	**15%**	**5%**	**7%**	**18%**	**3%**	**6%**	**6%**	**6%**	**3%**	**6%**	**2%**	**5%**	**13%**	**4%**	**4%**	**4%**
Max RSD	**25%**	**14%**	**61%**	**50%**	**17%**	**21%**	**113%**	**6%**	**28%**	**24%**	**16%**	**7%**	**28%**	**5%**	**10%**	**61%**	**14%**	**11%**	**21%**

Sample	Zr ppm
101-1-180um	37.8
101-1-180um_replicate	36.3
Ave	37.05
RSD	3%
116-1-180um	24.6
116-1-180um_replicate	29.8
Ave	27.2
RSD	14%
132-1-180um	91.9
132-1-180um_replicate	86.7
Ave	89.3
RSD	4%
108-2-180um	75.7
108-2-180um_replicate	71.8
Ave	73.75
RSD	4%
124-2-180um	70
124-2-180um_replicate	67
Ave	68.5
RSD	3%
136-2-180um	84.5
136-2-180um_replicate	86.4
Ave	85.45
RSD	2%
108-1-75um	152.8
108-1-75um_replicate	154.9
Ave	153.85
RSD	1%
124-1-75um	106
124-1-75um_replicate	109
Ave	107.5
RSD	2%
136-1-75um	86.5
136-1-75um_replicate	97.7

Sample	Zr ppm
Ave	92.1
RSD	9%
101-2-75um	19.2
101-2-75um_replicate	23
Ave	21.1
RSD	13%
119-2-75um	100.4
119-2-75um_replicate	103.6
Ave	102
RSD	2%
132-2-75um	117.7
132-2-75um_replicate	116.7
Ave	117.2
RSD	1%
Min RSD	**1%**
Ave RSD	**5%**
Max RSD	**14%**

Appendix 3.2.3. GF-AAS analysis for Au (regolith)

Average and Relative Standard Deviation (RSD) shown in green below data.
(Relative Standard Deviation = 100 % x Standard Deviation / Average)
Numbers in red were reported as <LLD and are set to 0.5 LLD (Lower Limit of Detection)

Sample	SampleID	Au mg/kg
20058511371 (<180 um)	20058511371 (<180 um)	0.0002
Replicate	20058511011, <180	0.00005
Average		0.0001
RSD		85%
20058511372 (<75 um)	20058511372 (<75 um)	0.0007
Replicate	20058511012, <75	0.0007
Average		0.0007
RSD		0%
20058511381 (<75 um)	20058511381 (<75 um)	0.0002
Replicate	20058511081, <75	0.0004
Average		0.0003
RSD		47%
20058511382 (<180 um)	20058511382 (<180 um)	0.0005
Replicate	20058511082, <180	0.0134
Average		0.0070
RSD		131%
20058511391 (<180 um)	20058511391 (<180 um)	0.00005
Replicate	20058511161, <180	0.0001
Average		0.0001
RSD		47%
20058511402 (<75 um)	20058511402 (<75 um)	0.0051
Replicate	20058511192, <75	0.005
Average		0.0051
RSD		1%
20058511411 (<75 um)	20058511411 (<75 um)	0.00005
Replicate	20058511241, <75	0.0001
Average		0.0001
RSD		47%
20058511412 (<180 um)	20058511412 (<180 um)	0.00005
Replicate	20058511242, <180	0.0001
Average		0.0001
RSD		47%
20058511421 (<180 um)	20058511421 (<180 um)	0.0002
Replicate	20058511321, <180	0.0003
Average		0.0003
RSD		28%
20058511422 (<75 um)	20058511422 (<75 um)	0.0017
Replicate	20058511322, <75	0.002
Average		0.0019
RSD		11%
20058511431 (<75 um)	20058511431 (<75 um)	0.0003
Replicate	20058511361, <75	0.0004
Average		0.0004
RSD		20%
20058511432 (<180 um)	20058511432 (<180 um)	0.0013
Replicate	20058511362, <180	0.0005
Average		0.0009
RSD		63%
2006031301	2006031301	0.0002
Replicate	20058511082 (<180 um)	0.0134
Average		0.0068
RSD		137%

	2006031302	2006031302	0.001
Replicate		20058511082 (<75 um)	0.0037
Average			0.0024
RSD			81%
	2006031303	2006031303	0.0019
Replicate		20058511102 (<75 um)	0.0038
Average			0.0029
RSD			47%
	2006031304	2006031304	0.0002
Replicate		20058511141 (<75 um)	0.0036
Average			0.0019
RSD			127%
	2006031305	2006031305	0.0027
Replicate		20058511332 (<75 um)	0.0038
Average			0.0033
RSD			24%
	2006031306	2006031306	0.0001
Replicate		2004851001001<75	0.0001
Average			0.0001
RSD			0%
	2006031307	2006031307	0.0018
Replicate		2004851009002<180	0.0008
Average			0.0013
RSD			54%
Min RSD			**0%**
Ave RSD			**53%**
Max RSD			**137%**

Note: Values <LLD have been halved (= 0.5 LLD)

Appendix 3.2.4. ISE analysis for F (regolith)

Average and Relative Standard Deviation (RSD) shown in green below data.
(Relative Standard Deviation = 100 % x Standard Deviation / Average)

Sample	SampleID	F mg/kg
20058511371 (<180 um)	20058511371 (<180 um)	210
Replicate	20058511011, <180	160
Average		185
RSD		19%
20058511372 (<75 um)	20058511372 (<75 um)	340
Replicate	20058511012, <75	310
Average		325
RSD		7%
20058511381 (<75 um)	20058511381 (<75 um)	260
Replicate	20058511081, <75	230
Average		245
RSD		9%
20058511382 (<180 um)	20058511382 (<180 um)	260
Replicate	20058511082, <180	230
Average		245
RSD		9%
20058511391 (<180 um)	20058511391 (<180 um)	110
Replicate	20058511161, <180	90
Average		100
RSD		14%
20058511402 (<75 um)	20058511402 (<75 um)	260
Replicate	20058511192, <75	260
Average		260
RSD		0%
20058511411 (<75 um)	20058511411 (<75 um)	220
Replicate	20058511241, <75	190
Average		205
RSD		10%
20058511412 (<180 um)	20058511412 (<180 um)	190
Replicate	20058511242, <180	160
Average		175
RSD		12%
20058511421 (<180 um)	20058511421 (<180 um)	220
Replicate	20058511321, <180	210
Average		215
RSD		3%
20058511422 (<75 um)	20058511422 (<75 um)	300
Replicate	20058511322, <75	300
Average		300
RSD		0%
20058511431 (<75 um)	20058511431 (<75 um)	420
Replicate	20058511361, <75	310
Average		365
RSD		21%
20058511432 (<180 um)	20058511432 (<180 um)	440
Replicate	20058511362, <180	370
Average		405
RSD		12%
2006031308	2006031308	620
Replicate	20058511112 (<180 um)	1270
Average		945
RSD		49%

	2006031309	2006031309	1540
Replicate		20058511112 (<75 um)	1700
Average			1620
RSD			7%
	2006031310	2006031310	550
Replicate		20058511111 (< 75um)	640
Average			595
RSD			11%
	2006031311	2006031311	380
Replicate		20058511361 (<180 um)	330
Average			355
RSD			10%
	2006031312	2006031312	270
Replicate		2004851001002<180	330
Average			300
RSD			14%
	2006031313	2006031313	220
Replicate		2004851006001<75	240
Average			230
RSD			6%
Min RSD			**0%**
Ave RSD			**12%**
Max RSD			**49%**

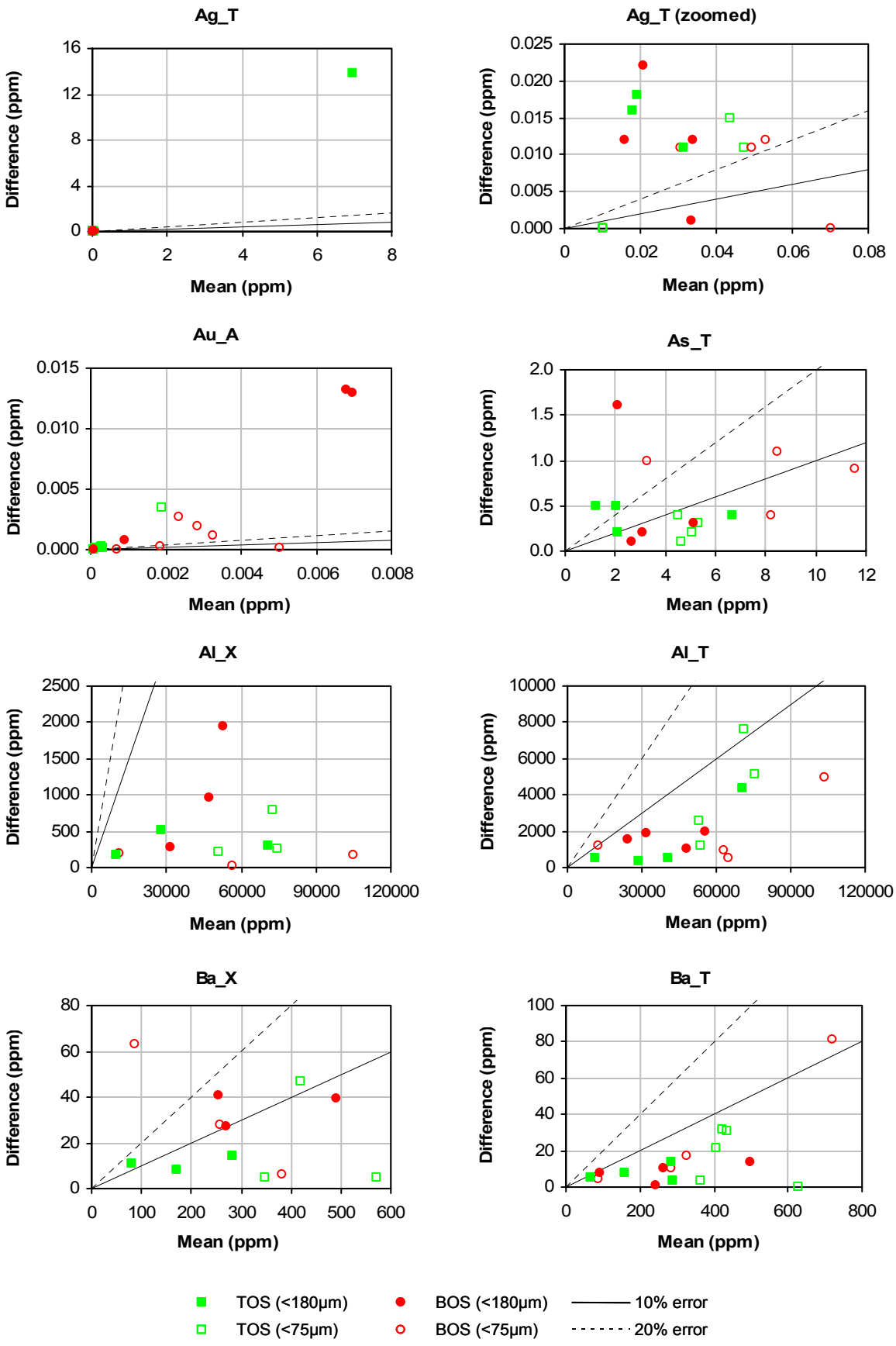
Appendix 3.2.5. ICP-MS analysis for Se (regolith)

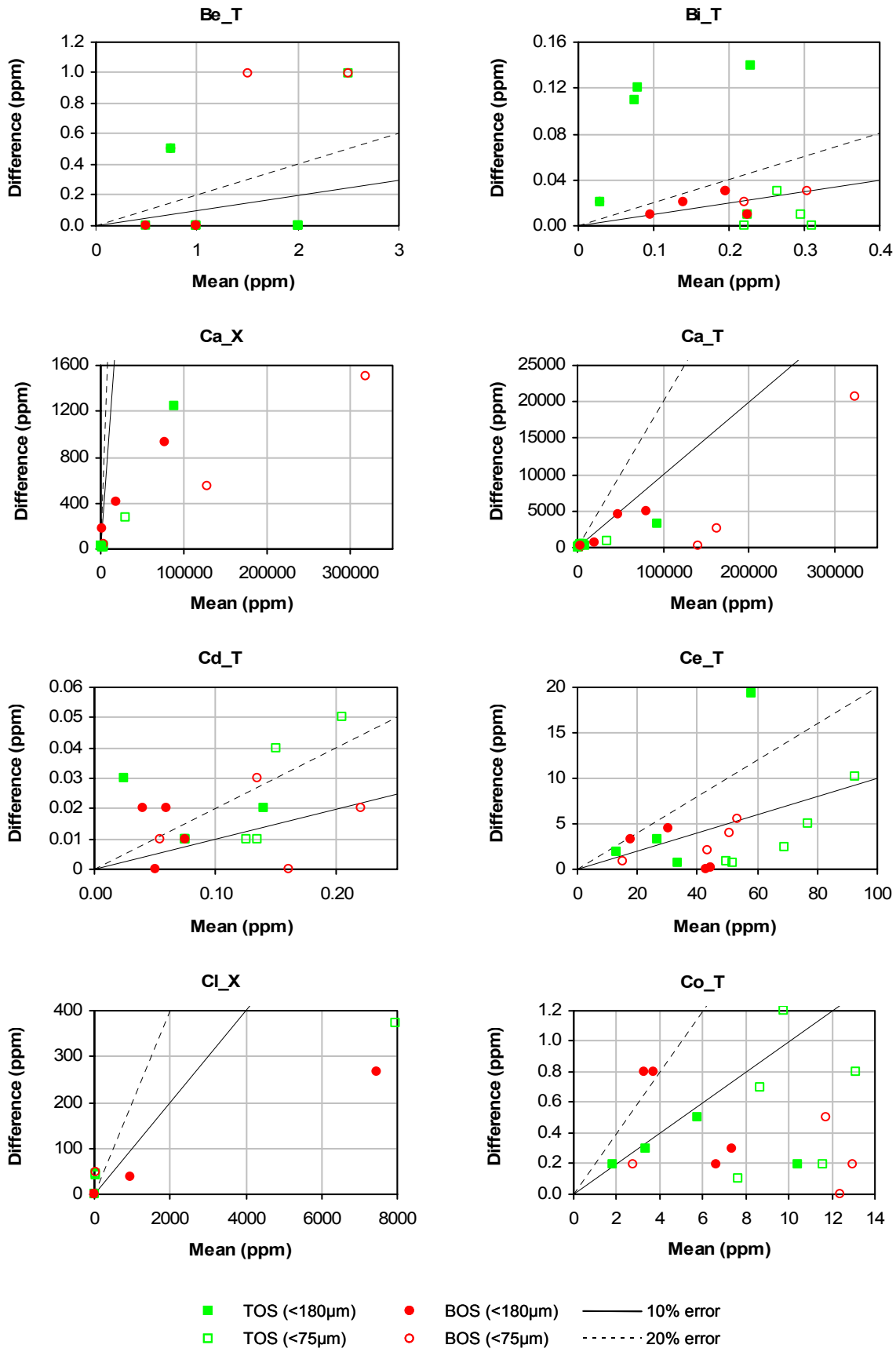
Average and Relative Standard Deviation (RSD) shown in green below data.
(Relative Standard Deviation = 100 % x Standard Deviation / Average)

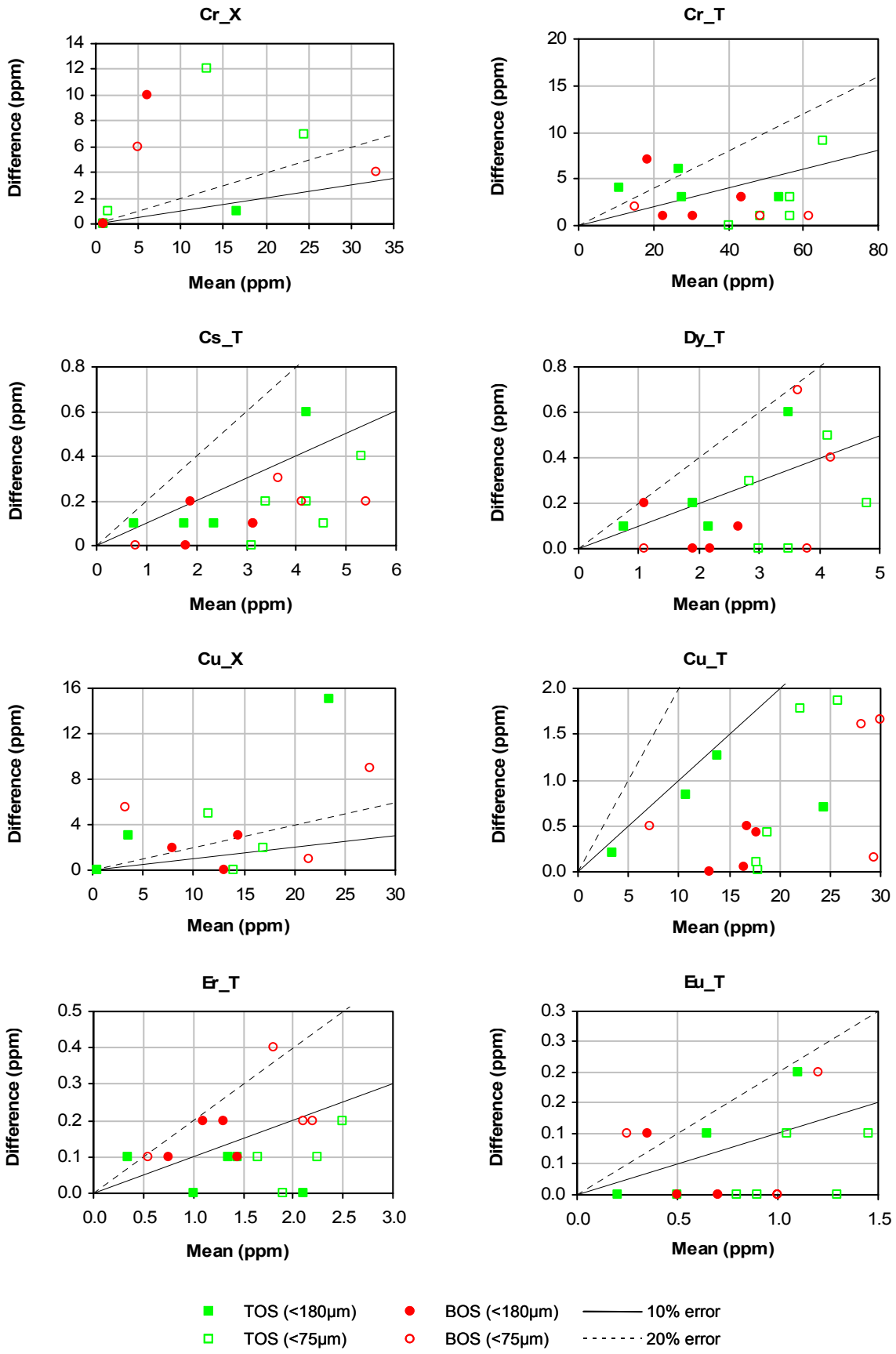
Sample	SampleID	Se mg/kg
20058511011<180	20058511011<180	0.255
Replicate	20058511371	0.243
Average		0.249
RSD		3%
20058511161<180	20058511161<180	0.115
Replicate	20058511391	0.130
Average		0.123
RSD		8%
20058511321<180	20058511321<180	0.236
Replicate	20058511421	0.286
Average		0.261
RSD		13%
20058511091<75	20058511091<75	0.261
Replicate	20058511451	0.300
Average		0.280
RSD		10%
20058511251<75	20058511251<75	0.238
Replicate	20058511471	0.246
Average		0.242
RSD		2%
20058511351<75	20058511351<75	0.234
Replicate	20058511491	0.237
Average		0.236
RSD		1%
20058511082<180	20058511082<180	0.469
Replicate	20058511382	0.483
Average		0.476
RSD		2%
20058511242<180	20058511242<180	0.160
Replicate	20058511412	0.151
Average		0.156
RSD		4%
20058511362<180	20058511362<180	0.453
Replicate	20058511432	0.474
Average		0.464
RSD		3%
20058511022<75	20058511022<75	0.784
Replicate	20058511442	0.880
Average		0.832
RSD		8%
20058511202<75	20058511202<75	0.383
Replicate	20058511462	0.419
Average		0.401
RSD		6%
20058511332<75	20058511332<75	0.422
Replicate	20058511482	0.455
Average		0.439
RSD		5%
Min RSD		**1%**
Ave RSD		**6%**
Max RSD		**13%**

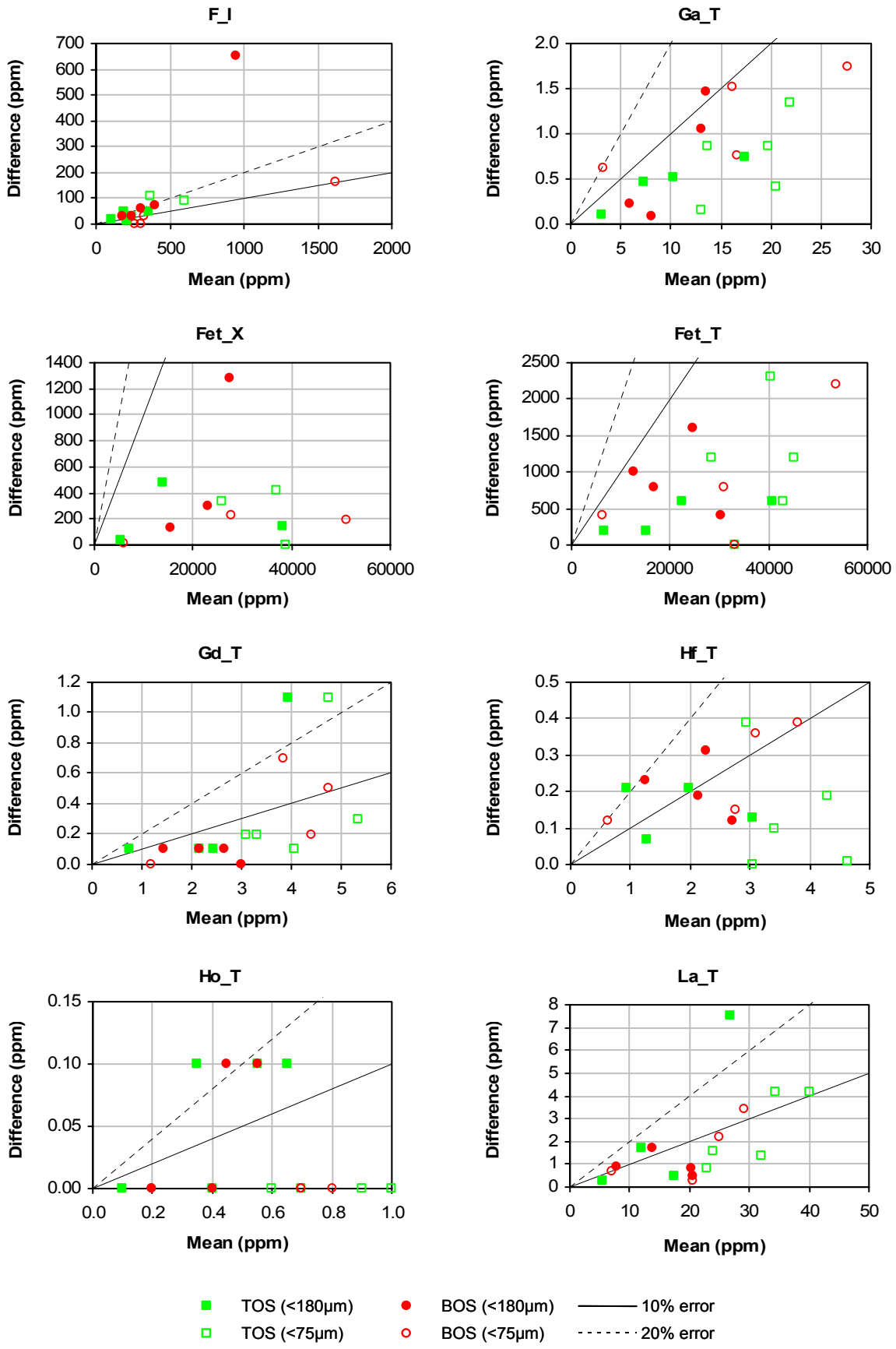
Appendix 3.2.6. Duplicate plots (regolith)

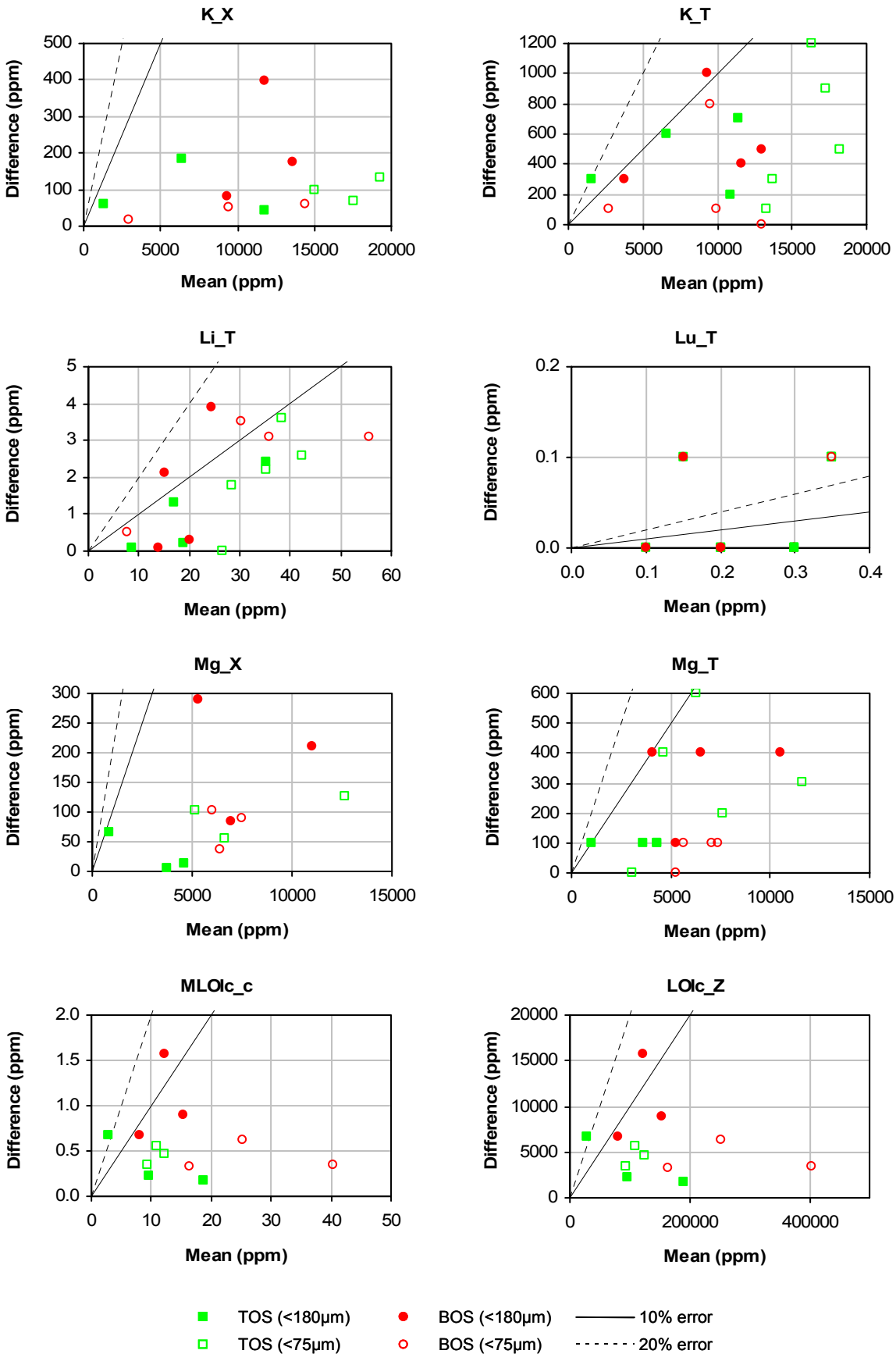
"Thompson and Howarth" plots (Thompson and Howarth, 1978) of absolute difference (|D1 – D2|) versus mean ([D1 + D2]/2) of duplicate analyses (see Reimann *et al*., 2008)
Suffix indicates analytical method (A: GF-AAS at ALS Chemex Lab; I: ISE at ALS Chemex Lab; T: ICP-MS at Acme Lab; X: XRF at GA Lab; Z: calculated). See text for details

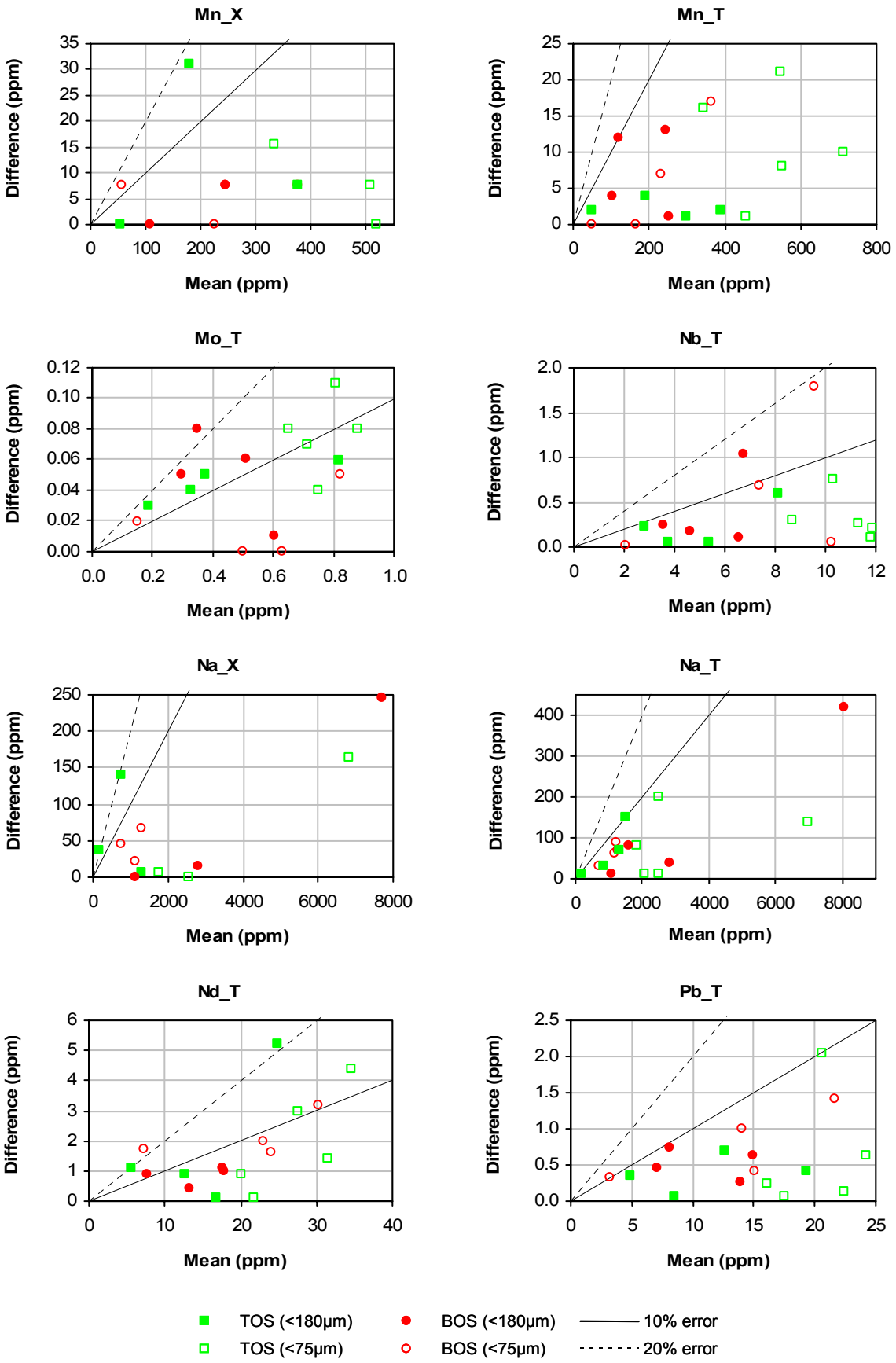

Ag_T
Ag_T (zoomed)
Au_A
As_T
Al_X
Al_T
Ba_X
Ba_T
Difference (ppm)
Mean (ppm)
TOS (<180µm)
TOS (<75µm)
BOS (<180µm)
BOS (<75µm)
10% error
20% error

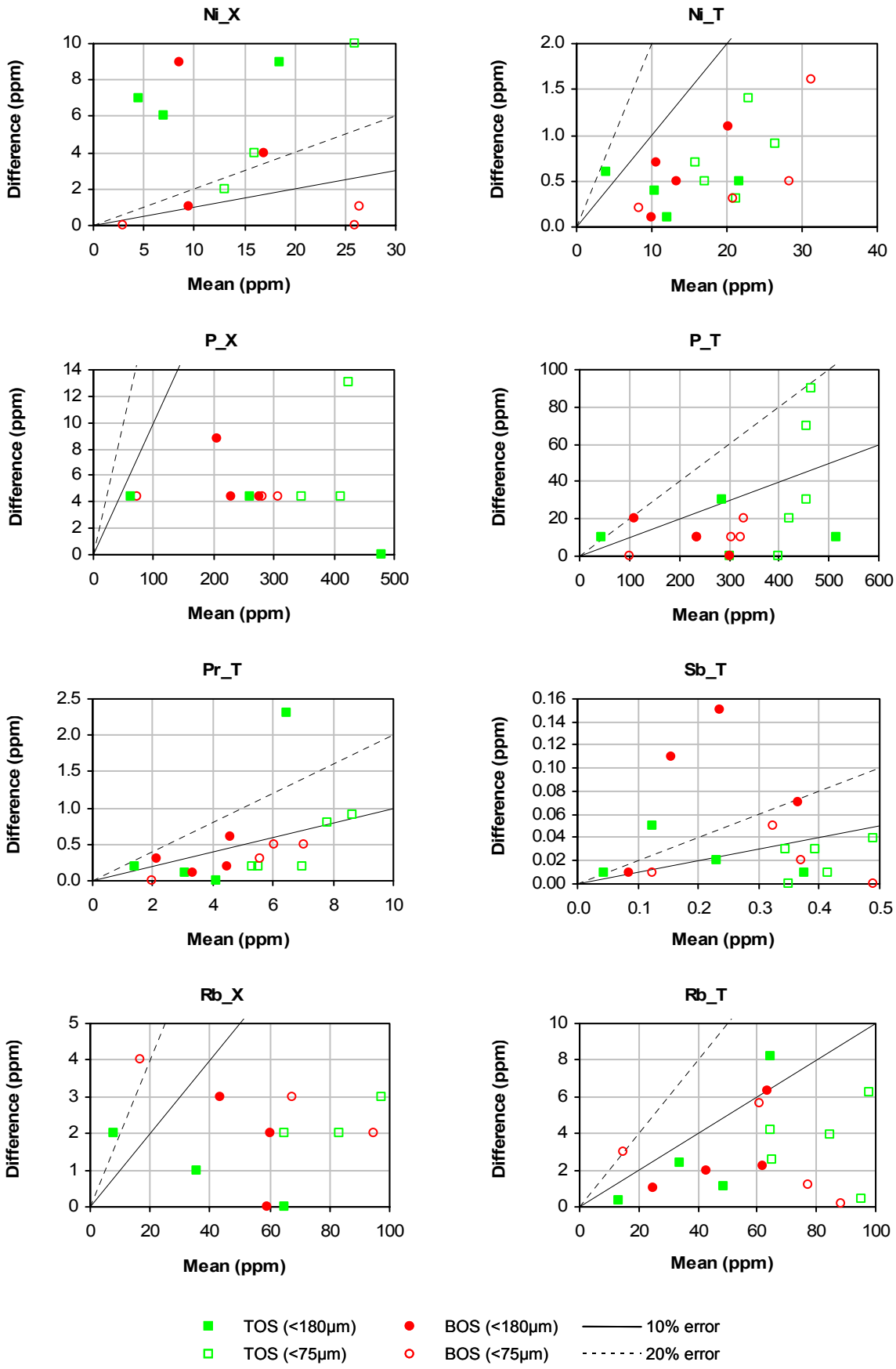

Be_T
Bi_T
Ca_X
Ca_T
Cd_T
Ce_T
Cl_X
Co_T
Difference (ppm)
Mean (ppm)
TOS (<180µm)
TOS (<75µm)
BOS (<180µm)
BOS (<75µm)
10% error
20% error

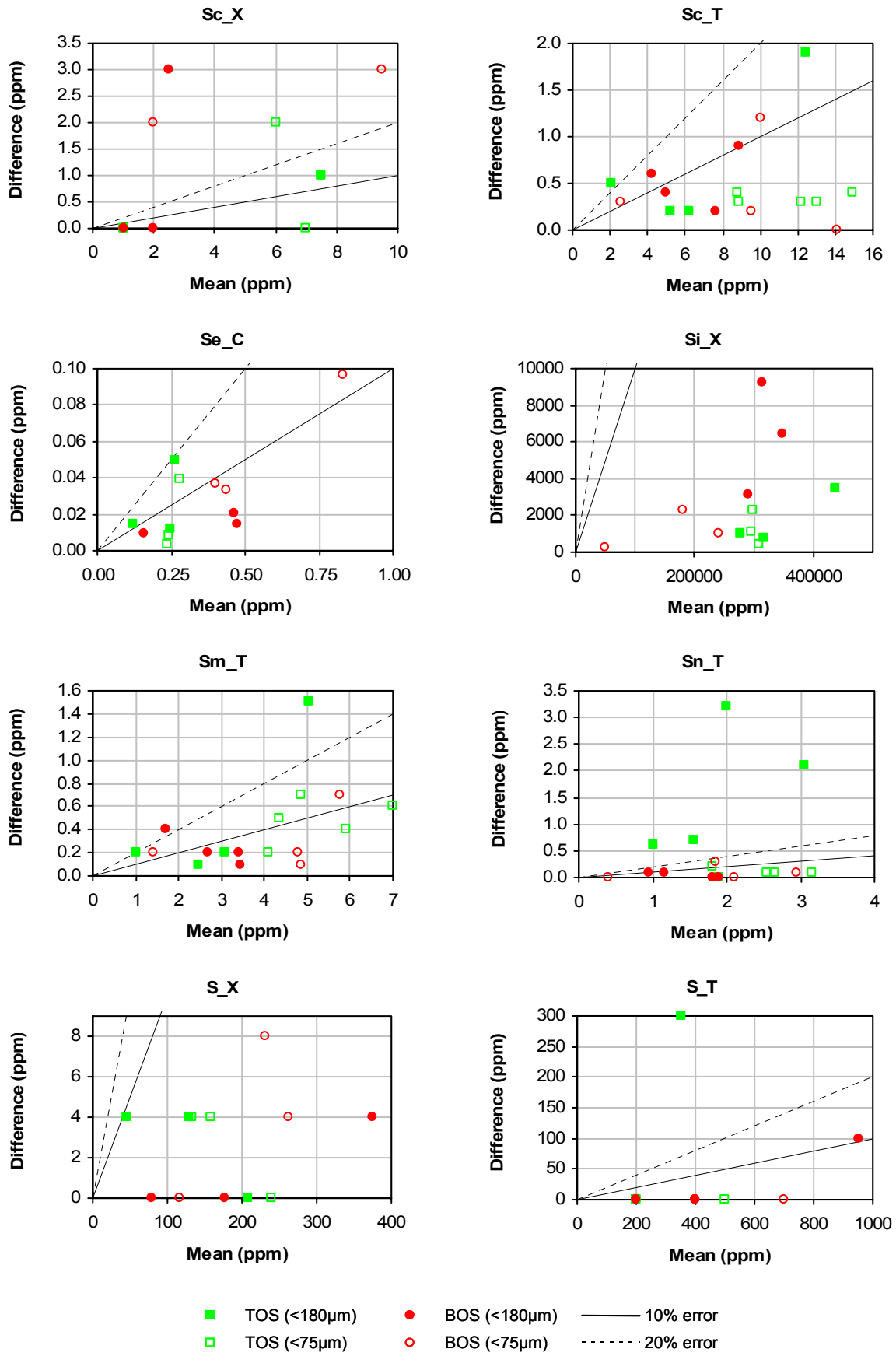

Cr_X
Cr_T
Cs_T
Dy_T
Cu_X
Cu_T
Er_T
Eu_T
Difference (ppm)
Mean (ppm)
TOS (<180µm)
TOS (<75µm)
BOS (<180µm)
BOS (<75µm)
10% error
20% error

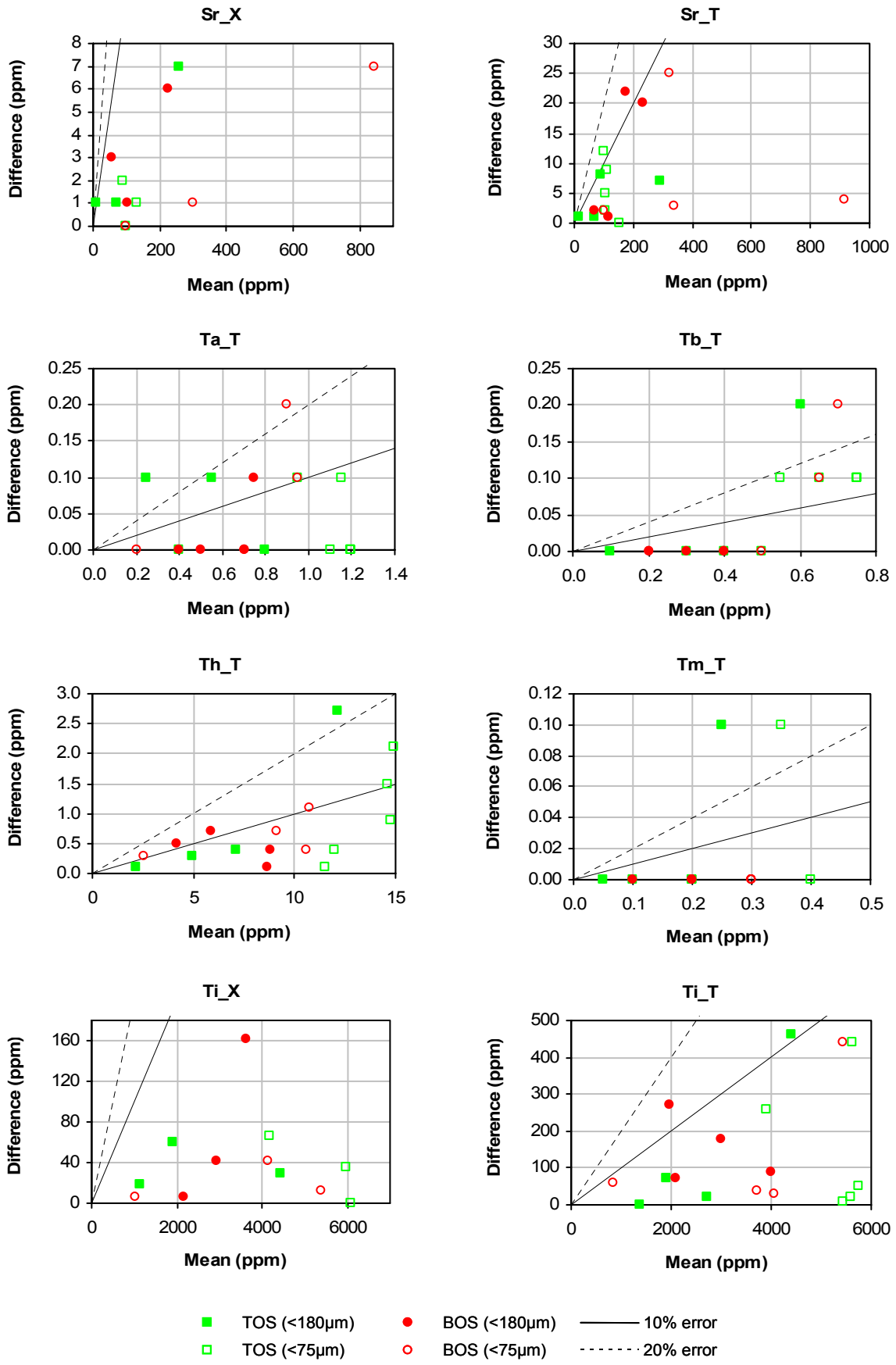

F_I
Ga_T
Fet_X
Fet_T
Gd_T
Hf_T
Ho_T
La_T
Difference (ppm)
Mean (ppm)
TOS (<180µm)
TOS (<75µm)
BOS (<180µm)
BOS (<75µm)
10% error
20% error

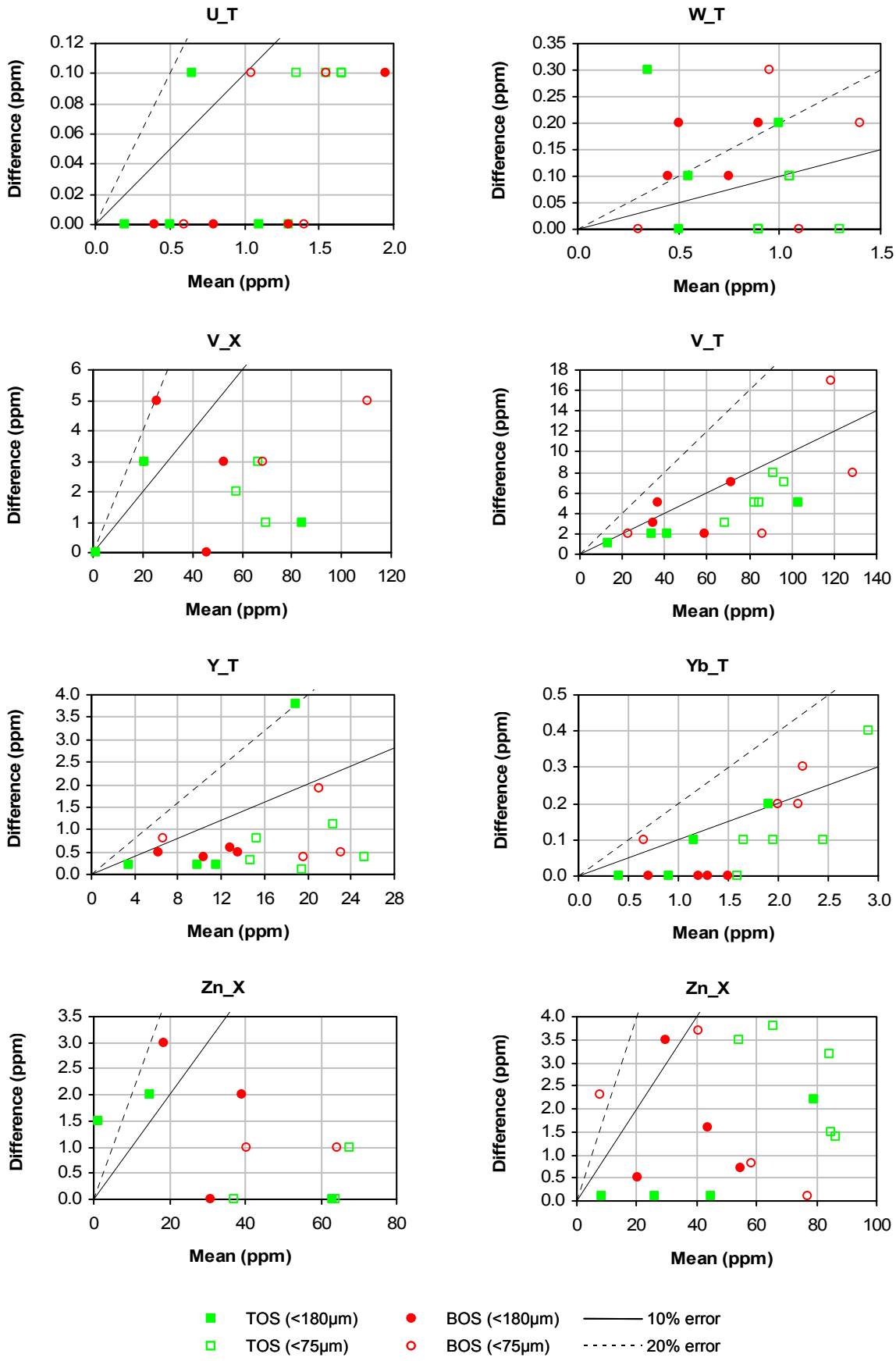

K_X
K_T
Li_T
Lu_T
Mg_X
Mg_T
MLOlc_c
LOlc_Z
Difference (ppm)
Mean (ppm)
TOS (<180µm)
BOS (<180µm)
10% error
TOS (<75µm)
BOS (<75µm)
20% error

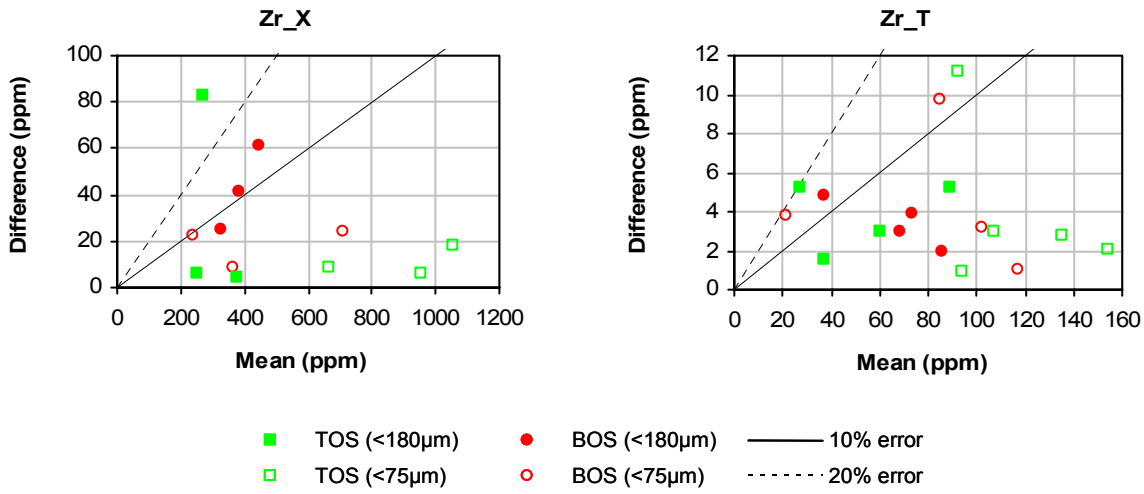

Mn_X
Mn_T
Mo_T
Nb_T
Na_X
Na_T
Nd_T
Pb_T
Difference (ppm)
Mean (ppm)
TOS (<180µm)
TOS (<75µm)
BOS (<180µm)
BOS (<75µm)
10% error
20% error


Ni_X
Ni_T
P_X
P_T
Pr_T
Sb_T
Rb_X
Rb_T
Difference (ppm)
Mean (ppm)
TOS (<180µm)
TOS (<75µm)
BOS (<180µm)
BOS (<75µm)
10% error
20% error


Sc_X
Sc_T
Se_C
Si_X
Sm_T
Sn_T
S_X
S_T
Difference (ppm)
Mean (ppm)
TOS (<180µm)
TOS (<75µm)
BOS (<180µm)
BOS (<75µm)
10% error
20% error


Sr_X
Sr_T
Ta_T
Tb_T
Th_T
Tm_T
Ti_X
Ti_T
Difference (ppm)
Mean (ppm)
TOS (<180µm)
TOS (<75µm)
BOS (<180µm)
BOS (<75µm)
10% error
20% error


U_T
W_T
V_X
V_T
Y_T
Yb_T
Zn_X
Zn_X
Difference (ppm)
Mean (ppm)
TOS (<180µm)
TOS (<75µm)
BOS (<180µm)
BOS (<75µm)
10% error
20% error


Zr_X
Difference (ppm)
Mean (ppm)
0
20
40
60
80
100
0
200
400
600
800
1000
1200
Zr_T
Difference (ppm)
Mean (ppm)
0
2
4
6
8
10
12
0
20
40
60
80
100
120
140
160
TOS (<180µm)
TOS (<75µm)
BOS (<180µm)
BOS (<75µm)
10% error
20% error

Appendix 3.2.7. ICP-ES and IC analysis for multiple elements (groundwater)

Average and Relative Standard Deviation (RSD) shown in green below data.
(Relative Standard Deviation = 100 % x Standard Deviation / Average)
Numbers in red were reported as <LLD and are set to 0.5 LLD (Lower Limit of Detection)

Sample	SampleID	Al	B	Ba	Ca	Cu	Fe	K	Li	Mg	Mn	Na	Si
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
G005	**G005**	0.020	3.13	0.064	349	0.0015	0.232	46.0	0.050	194	0.008	1338	30.2
Replicate	**GD2**	0.016	3.04	0.063	340	0.0015	0.291	42.1	0.050	195	2.90	1310	28.1
Average		0.017952	3.085874	0.06323	344.3614	0.0015	0.261449	44.0373	0.05	194.2558	1.45306	1324.427	29.1555
RSD		17%	2%	1%	2%	0%	16%	6%	0%	0%	141%	1%	5%
G010	**G010**	0.017	5.71	0.031	275	0.059	1.35	79.9	0.050	343	0.257	3526	22.2
Replicate	**GD1**	0.022	5.94	0.033	273	0.053	1.20	82.4	0.050	335	0.254	3517	22.6
Average		0.019471	5.823374	0.031898	273.9531	0.056116	1.274904	81.1468	0.05	339.1796	0.255361	3521.466	22.36502
RSD		19%	3%	3%	1%	7%	8%	2%	0%	2%	1%	0%	1%
210	**210**	0.050	1.97	0.001	343	0.037	0.005	44.7	0.056	168	0.001	1049	27.4
Replicate	**224**	0.050	1.97	0.001	345	0.037	0.005	43.6	0.056	168	0.001	1071	27.3
Average		0.05	1.973016	0.001	344.4644	0.03693	0.005	44.18114	0.056418	168.1366	0.001	1059.814	27.34738
RSD		0%	0%	0%	0%	0%	0%	2%	0%	0%	0%	1%	0%
215	**215**	0.050	4.22	0.031	428	0.038	0.005	34.2	0.053	296	0.001	2815	26.3
Replicate	**225**	0.050	4.20	0.031	411	0.038	0.005	32.0	0.053	266	0.001	2755	26.1
Average		0.05	4.210364	0.031011	419.8064	0.037827	0.005	33.06676	0.052925	281.2052	0.001	2784.971	26.17852
RSD		0%	0%	0%	3%	1%	0%	5%	1%	8%	0%	2%	0%
220	**220**	0.050	1.03	0.051	76.8	0.0015	0.005	40.1	0.050	30.8	0.001	407	30.0
Replicate	**223**	0.050	0.939	0.044	77.7	0.0015	0.005	40.8	0.050	31.4	0.001	410	28.2
Average		0.05	0.982092	0.047576	77.26626	0.0015	0.005	40.47243	0.05	31.09119	0.001	408.7222	29.11424
RSD		0%	6%	12%	1%	0%	0%	1%	0%	1%	0%	1%	4%
Min RSD		**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**1%**	**0%**	**0%**	**0%**	**0%**	**0%**
Ave RSD		**7%**	**2%**	**3%**	**1%**	**2%**	**5%**	**3%**	**0%**	**2%**	**28%**	**1%**	**2%**
Max RSD		**19%**	**6%**	**12%**	**3%**	**7%**	**16%**	**6%**	**1%**	**8%**	**141%**	**2%**	**5%**

Note: Values <LLD have been halved (= 0.5 LLD)

Sample	Sr	Zn	F	Cl	Br	NO3	PO4	SO4
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
G005	8.19	0.249						
Replicate	5.27	3.48						
Average	6.728093	1.866766						
RSD	31%	123%						
G010	5.62	0.736						
Replicate	5.58	0.725						
Average	5.598407	0.730583						
RSD	0%	1%						
210	5.00	0.050	2.8	2255	12	135	0.00	527
Replicate	5.01	0.050	2.9	2276	13	135	0.00	532
Average	5.005433	0.05	2.876893	2265.504	12.52743	135.2562		529.357
RSD	0%	0%	2%	1%	1%	0%		1%
215	6.73	0.016	2.5	5187	19	70	0.00	754
Replicate	6.69	0.020	2.1	5227	21	72	0.00	762
Average	6.709889	0.018087	2.285717	5206.843	20.35342	71.2092		758.2193
RSD	0%	13%	12%	1%	7%	2%		1%
220	1.17	0.069	0.64	562	2.4	65	0.00	141
Replicate	1.09	0.059	0.66	564	2.4	66	0.00	140
Average	1.128801	0.063657	0.653786	562.7713	2.430602	65.53306		140.5694
RSD	5%	11%	2%	0%	0%	0%		0%
Min RSD	**0%**	**0%**	**2%**	**0%**	**0%**	**0%**		**0%**
Ave RSD	**7%**	**29%**	**5%**	**0%**	**3%**	**1%**		**1%**
Max RSD	**31%**	**123%**	**12%**	**1%**	**7%**	**2%**		**1%**

Appendix 3.2.8. ICP-MS analysis for multiple elements (groundwater)

Average and Relative Standard Deviation (RSD) shown in green below data.
(Relative Standard Deviation = 100 % x Standard Deviation / Average)
Numbers in red were reported as <LLD and are set to 0.5 LLD (Lower Limit of Detection)

Sample	SampleID	Ag	Al	As	B	Ba	Be	Bi	Cd	Ce	Co	Cr	Cs	Cu	Dy	Er	Eu	Fe	Ga	Gd	Gd	Ge	Hf	Ho	La	Li
		ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
G005	G005	0.5	0.5	0.5	2251.6	46.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	25.4	0.5	0.5	0.5	261.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Replicate	GD 2	0.5	0.5	0.5	2350.8	47.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	21.3	0.5	0.5	0.5	250.3	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Average		0.5	0.5	0.5	2301.2	47.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	23.4	0.5	0.5	0.5	255.7	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
RSD		0%	0%	0%	3%	1%	0%	0%	0%	0%	0%	0%	0%	12%	0%	0%	0%	3%	0%	0%	0%	0%	0%	0%	0%	0%
G010	G010	0.5	0.5	0.5	3987.8	24.9	0.5	0.5	0.5	0.5	0.5	0.5	0.5	58.3	0.5	0.5	0.5	1317.3	0.5	0.5	0.5	0.5	0.5	0.5	0.5	76.0
Replicate	GD 1	0.5	0.5	0.5	3871.2	24.9	0.5	0.5	0.5	0.5	0.5	0.5	0.5	56.3	0.5	0.5	0.5	1291.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	75.7
Average		0.5	0.5	0.5	3929.5	24.9	0.5	0.5	0.5	0.5	0.5	0.5	0.5	57.3	0.5	0.5	0.5	1304.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	75.9
RSD		0%	0%	0%	2%	0%	0%	0%	0%	0%	0%	0%	0%	2%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%
210 FA	210 FA	0.5	0.5	3.0	1093.3	5.1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	19.2	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	37.1
Replicate	224 FA	0.5	0.5	3.3	832.9	5.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	22.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	38.3
Average		0.5	0.5	3.1	963.1	5.1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	20.9	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	37.7
RSD		0%	0%	8%	19%	0%	0%	0%	0%	0%	0%	0%	0%	12%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	2%
215 FA	215 FA	0.5	0.5	4.2	1793.6	38.1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	14.8	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	40.6
Replicate	225 FA	0.5	1.1	3.2	1543.7	38.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	15.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	41.2
Average		0.5	0.8	3.7	1668.7	38.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	14.9	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	40.9
RSD		0%	52%	21%	11%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%
220 FA	220 FA	0.5	0.5	12.2	368.4	63.1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	4.8	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	5.1
Replicate	223 FA	0.5	0.5	12.0	317.3	61.7	0.5	0.5	0.5	0.5	0.5	0.5	0.5	4.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	4.5
Average		0.5	0.5	12.1	342.9	62.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	4.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	4.8
RSD		0%	0%	1%	11%	2%	0%	0%	0%	0%	0%	0%	0%	7%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	8%
Min RSD		**0%**	**0%**	**0%**	**2%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**1%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**
Ave RSD		**0%**	**10%**	**6%**	**9%**	**1%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**7%**	**0%**	**0%**	**0%**	**1%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**2%**
Max RSD		**0%**	**52%**	**21%**	**19%**	**2%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**12%**	**0%**	**0%**	**0%**	**3%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**8%**

Note: Values <LLD have been halved (= 0.5 LLD)
FA: Filtered (0.45 um) and acidified (ultrapure HNO3)

Sample	Lu	Mn	Mo	Nb	Nd	Ni	Pb	Pr	Rb	Sb	Sc	Sm	Sn	Sr	Ta	Tb	Th	U	V	W	Y	Yb	Zn	Zr
	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
G005	0.5	0.5	0.5	0.5	0.5	17.5	24.1	0.5	22.3	0.5	0.5	0.5	0.5	6071.0	0.5	0.5	0.5	10.4	113.8	0.5	0.5	0.5	356.3	0.5
Replicate	0.5	0.5	0.5	0.5	0.5	17.4	0.5	0.5	22.3	0.5	0.5	0.5	0.5	6095.3	0.5	0.5	0.5	9.5	109.8	0.5	0.5	0.5	339.1	0.5
Average	0.5	0.5	0.5	0.5	0.5	17.4	12.3	0.5	22.3	0.5	0.5	0.5	0.5	6083.1	0.5	0.5	0.5	10.0	111.8	0.5	0.5	0.5	347.7	0.5
RSD	0%	0%	0%	0%	0%	0%	136%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	7%	3%	0%	0%	0%	3%	0%
G010	0.5	237.8	0.5	0.5	0.5	18.5	0.5	0.5	45.0	0.5	0.5	0.5	0.5	6517.6	0.5	0.5	4.8	6.2	0.5	0.5	0.5	0.5	724.5	0.5
Replicate	0.5	236.0	0.5	0.5	0.5	16.9	0.5	0.5	44.2	0.5	0.5	0.5	0.5	6492.1	0.5	0.5	4.0	6.1	0.5	0.5	0.5	0.5	729.6	0.5
Average	0.5	236.9	0.5	0.5	0.5	17.7	0.5	0.5	44.6	0.5	0.5	0.5	0.5	6504.9	0.5	0.5	4.4	6.1	0.5	0.5	0.5	0.5	727.0	0.5
RSD	0%	1%	0%	0%	0%	7%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	13%	2%	0%	0%	0%	0%	0%	0%
210 FA	0.5	0.5	12.4	0.5	0.5	1.0	0.5	0.5	8.1	0.5	5.1	0.5	0.5	5465.6	0.5	0.5	0.5	25.7	0.5	0.5	0.5	0.5	6.2	0.5
Replicate	0.5	0.5	12.5	0.5	0.5	1.3	0.5	0.5	8.9	0.5	6.2	0.5	0.5	5352.8	0.5	0.5	0.5	29.8	1.3	0.5	0.5	0.5	7.6	0.5
Average	0.5	0.5	12.4	0.5	0.5	1.2	0.5	0.5	8.5	0.5	5.6	0.5	0.5	5409.2	0.5	0.5	0.5	27.7	0.9	0.5	0.5	0.5	6.9	0.5
RSD	0%	0%	1%	0%	0%	16%	0%	0%	6%	0%	15%	0%	0%	1%	0%	0%	0%	10%	63%	0%	0%	0%	14%	0%
215 FA	0.5	2.2	4.5	0.5	0.5	2.0	0.5	0.5	9.2	0.5	6.9	0.5	0.5	7269.8	0.5	0.5	0.5	10.9	8.8	0.5	0.5	0.5	13.6	0.5
Replicate	0.5	2.4	4.1	0.5	0.5	3.4	0.5	0.5	8.9	0.5	6.9	0.5	0.5	6933.8	0.5	0.5	0.5	10.5	7.0	0.5	0.5	0.5	13.6	0.5
Average	0.5	2.3	4.3	0.5	0.5	2.7	0.5	0.5	9.0	0.5	6.9	0.5	0.5	7101.8	0.5	0.5	0.5	10.7	7.9	0.5	0.5	0.5	13.6	0.5
RSD	0%	5%	7%	0%	0%	38%	0%	0%	2%	0%	0%	0%	0%	3%	0%	0%	0%	2%	17%	0%	0%	0%	0%	0%
220 FA	0.5	0.5	6.3	0.5	0.5	0.5	0.5	0.5	8.3	0.5	6.8	0.5	0.5	1227.9	0.5	0.5	0.5	3.9	113.2	0.5	0.5	0.5	37.0	0.5
Replicate	0.5	0.5	6.0	0.5	0.5	0.5	0.5	0.5	7.8	0.5	5.9	0.5	0.5	1183.3	0.5	0.5	0.5	3.5	110.8	0.5	0.5	0.5	35.2	0.5
Average	0.5	0.5	6.1	0.5	0.5	0.5	0.5	0.5	8.0	0.5	6.4	0.5	0.5	1205.6	0.5	0.5	0.5	3.7	112.0	0.5	0.5	0.5	36.1	0.5
RSD	0%	0%	4%	0%	0%	0%	0%	0%	4%	0%	10%	0%	0%	3%	0%	0%	0%	8%	2%	0%	0%	0%	3%	0%
Min RSD	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**2%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**
Ave RSD	**0%**	**1%**	**2%**	**0%**	**0%**	**12%**	**27%**	**0%**	**3%**	**0%**	**5%**	**0%**	**0%**	**2%**	**0%**	**0%**	**3%**	**6%**	**17%**	**0%**	**0%**	**0%**	**4%**	**0%**
Max RSD	**0%**	**5%**	**7%**	**0%**	**0%**	**38%**	**136%**	**0%**	**6%**	**0%**	**15%**	**0%**	**0%**	**3%**	**0%**	**0%**	**13%**	**10%**	**63%**	**0%**	**0%**	**0%**	**14%**	**0%**

Appendix 3.3. Lab replicates

Appendix 3.3.1. ICP-MS analysis for multiple elements (regolith)

Average (Ave) and Relative Standard Deviation (RSD) shown in green below data.
(Relative Standard Deviation = 100 % x Standard Deviation / Average)
Numbers in red were reported as <LLD and are set to 0.5 LLD (Lower Limit of Detection)

Sample	SampleID	Ag	Al	As	Au	Ba	Be	Bi	Ca	Cd	Ce	Co	Cr	Cs	Cu	Dy	Er	Eu	Fe	Ga	Gd
		ppb	%	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm
130-1-180um	130-1-180um	10	4.01	1.8	0.05	291	1	0.02	0.95	0.07	33.04	5.5	26	2.3	13.22	2.1	1.3	0.6	2.2	10.05	2.4
130-1-180um	RE 130-1-180um	28	4.06	2.3	0.05	288	1	0.04	0.98	0.08	33.7	6	29	2.4	14.49	2.2	1.4	0.7	2.26	10.56	2.5
Ave		19	4.04	2.05	0.05	290	1	0.03	0.965	0.08	33.37	5.75	27.5	2.35	13.86	2.15	1.35	0.65	2.23	10.31	2.45
RSD		67%	1%	17%	0%	1%	0%	47%	2%	9%	1%	6%	8%	3%	6%	3%	5%	11%	2%	3%	3%
114-2-180um	114-2-180um	33	2.52	2.6	0.05	98	0.5	0.1	4.9	0.05	19.55	4.1	23	2	16.51	1.2	0.8	0.4	1.32	6.08	1.4
114-2-180um	RE 114-2-180um	34	2.37	2.7	0.05	90	0.5	0.09	4.45	0.03	16.27	3.3	22	1.8	16.46	1	0.7	0.3	1.22	5.86	1.5
Ave		33.5	2.45	2.65	0.05	94	0.5	0.095	4.675	0.04	17.91	3.7	22.5	1.9	16.49	1.1	0.75	0.35	1.27	5.97	1.45
RSD		2%	4%	3%	0%	6%	0%	7%	7%	35%	13%	15%	3%	7%	0%	13%	9%	20%	6%	3%	5%
105-1-75um	105-1-75um	53	7.84	6	0.05	452	2	0.31	0.7	0.13	97.82	11.7	58	5.5	23.01	4.9	2.6	1.5	4.59	22.6	5.5
105-1-75um	RE 105-1-75um	42	7.6	5.4	0.05	421	2	0.31	0.66	0.14	87.67	11.5	55	5.1	21.24	4.7	2.4	1.4	4.47	21.25	5.2
Ave		47.5	7.72	5.7	0.05	437	2	0.31	0.68	0.14	92.75	11.6	56.5	5.3	22.13	4.8	2.5	1.45	4.53	21.93	5.35
RSD		16%	2%	7%	0%	5%	0%	0%	4%	5%	8%	1%	4%	5%	6%	3%	6%	5%	2%	4%	4%
131-1-75um	131-1-75um	10	5.21	4.6	0.05	417	1	0.23	0.25	0.13	51.98	9	48	3.1	17.83	2.7	1.5	0.9	3.3	12.99	3.2
131-1-75um	RE 131-1-75um	10	5.47	4.7	0.05	396	1	0.22	0.26	0.12	51.3	8.3	49	3.1	17.73	3	1.4	0.9	3.3	13.14	3.4
Ave		10	5.34	4.65	0.05	407	1	0.225	0.255	0.13	51.64	8.65	48.5	3.1	17.78	2.85	1.45	0.9	3.3	13.07	3.3
RSD		0%	3%	2%	0%	4%	0%	3%	3%	6%	1%	6%	1%	0%	0%	7%	5%	0%	0%	1%	4%
133-2-75um	133-2-75um	47	6.55	11.1	0.05	682	1	0.18	16.18	0.16	48.82	11.5	42	3.5	27.3	3.3	1.6	1	3.33	15.34	3.5
133-2-75um	RE 133-2-75um	59	6.5	12	0.05	763	1	0.21	16.44	0.16	52.78	12	45	3.8	28.9	4	2	1	3.33	16.85	4.2
Ave		53	6.53	11.6	0.05	723	1	0.195	16.31	0.16	50.8	11.8	43.5	3.65	28.1	3.65	1.8	1	3.33	16.1	3.85
RSD		16%	1%	6%	0%	8%	0%	11%	1%	0%	6%	3%	5%	6%	4%	14%	16%	0%	0%	7%	13%
Min RSD		**0%**	**1%**	**2%**	**0%**	**1%**	**0%**	**0%**	**1%**	**0%**	**1%**	**1%**	**1%**	**0%**	**0%**	**3%**	**5%**	**0%**	**0%**	**1%**	**3%**
Ave RSD		**20%**	**2%**	**7%**	**0%**	**5%**	**0%**	**14%**	**3%**	**11%**	**6%**	**6%**	**4%**	**4%**	**3%**	**8%**	**8%**	**7%**	**2%**	**4%**	**6%**
Max RSD		**67%**	**4%**	**17%**	**0%**	**8%**	**0%**	**47%**	**7%**	**35%**	**13%**	**15%**	**8%**	**7%**	**6%**	**14%**	**16%**	**20%**	**6%**	**7%**	**13%**

Note: Values <LLD have been halved (= 0.5 LLD)

Sample	Hf	Ho	K	La	Li	Lu	Mg	Mn	Mo	Na	Nb	Nd	Ni	P	Pb	Pr	Rb	S	Sb	Sc	Sm	Sn	Sr
	ppm	ppm	%	ppm	ppm	ppm	%	ppm	ppm	%	ppm	ppm	ppm	%	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm
130-1-180um	1.88	0.4	1.08	17.1	19	0.2	0.43	301	0.35	0.145	5.4	16.7	12.2	0.027	12.24	4.1	48	0.02	0.22	6.1	3	1.3	69
130-1-180um	2.09	0.4	1.1	17.6	18.8	0.2	0.44	300	0.4	0.16	5.35	16.8	12.1	0.03	12.94	4.1	49.1	0.02	0.24	6.3	3.2	0.7	68
Ave	1.99	0.4	1.09	17.4	18.9	0.2	0.44	301	0.38	0.153	5.375	16.8	12.2	0.029	12.59	4.1	48.55	0.02	0.23	6.2	3.1	1	68.5
RSD	7%	0%	1%	2%	1%	0%	2%	0%	9%	7%	1%	0%	1%	7%	4%	0%	2%	0%	6%	2%	5%	42%	1%
114-2-180um	1.37	0.2	0.39	8.2	16.1	0.1	0.43	125	0.39	0.166	3.67	8.2	11	0.012	7.29	2.3	25.3	0.02	0.09	4.5	1.9	1	188
114-2-180um	1.14	0.2	0.36	7.3	14	0.1	0.39	113	0.31	0.158	3.42	7.3	10.3	0.01	6.84	2	24.3	0.02	0.08	3.9	1.5	0.9	166
Ave	1.26	0.2	0.38	7.75	15.1	0.1	0.41	119	0.35	0.162	3.545	7.75	10.7	0.011	7.065	2.15	24.8	0.02	0.09	4.2	1.7	0.95	177
RSD	13%	0%	6%	8%	10%	0%	7%	7%	16%	3%	5%	8%	5%	13%	5%	10%	3%	0%	8%	10%	17%	7%	9%
105-1-75um	4.39	1	1.85	42.3	43.7	0.4	0.77	719	0.86	0.249	11.74	36.9	23.6	0.051	24.56	9.1	94.7	0.02	0.51	14.7	7.3	3.2	109
105-1-75um	4.2	1	1.8	38.1	41.1	0.3	0.75	709	0.75	0.248	11.84	32.5	22.2	0.042	23.93	8.2	100.9	0.02	0.47	15.1	6.7	3.1	107
Ave	4.3	1	1.83	40.2	42.4	0.35	0.76	714	0.81	0.249	11.79	34.7	22.9	0.047	24.25	8.65	97.8	0.02	0.49	14.9	7	3.15	108
RSD	3%	0%	2%	7%	4%	20%	2%	1%	10%	0%	1%	9%	4%	14%	2%	7%	4%	0%	6%	2%	6%	2%	1%
131-1-75um	3.04	0.5	1.33	24.8	26.6	0.2	0.31	454	0.77	0.206	10.67	21.9	17.4	0.041	17.43	5.6	66.9	0.02	0.35	9	4.6	1.9	104
131-1-75um	3.04	0.6	1.32	23.2	26.6	0.2	0.31	455	0.73	0.207	9.91	21.8	16.9	0.043	17.5	5.4	62.7	0.02	0.35	8.7	4.1	1.9	92
Ave	3.04	0.55	1.33	24	26.6	0.2	0.31	455	0.75	0.207	10.29	21.9	17.2	0.042	17.47	5.5	64.8	0.02	0.35	8.85	4.35	1.9	98
RSD	0%	13%	1%	5%	0%	0%	0%	0%	4%	0%	5%	0%	2%	3%	0%	3%	5%	0%	0%	2%	8%	0%	9%
133-2-75um	2.68	0.7	0.91	24	28.5	0.3	0.71	166	0.5	0.116	7.06	23.3	20.7	0.032	13.59	5.8	58.3	0.04	0.3	9.4	4.9	1.7	309
133-2-75um	2.83	0.7	0.99	26.2	32	0.3	0.7	166	0.5	0.125	7.74	24.9	21	0.033	14.58	6.3	63.9	0.04	0.35	10.6	4.7	2	334
Ave	2.76	0.7	0.95	25.1	30.3	0.3	0.71	166	0.5	0.121	7.4	24.1	20.9	0.033	14.09	6.05	61.1	0.04	0.33	10	4.8	1.85	322
RSD	4%	0%	6%	6%	8%	0%	1%	0%	0%	5%	6%	5%	1%	2%	5%	6%	6%	0%	11%	8%	3%	11%	5%
Min RSD	**0%**	**0%**	**1%**	**2%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**1%**	**0%**	**1%**	**2%**	**0%**	**0%**	**2%**	**0%**	**0%**	**2%**	**3%**	**0%**	**1%**
Ave RSD	**5%**	**3%**	**3%**	**6%**	**5%**	**4%**	**2%**	**2%**	**8%**	**3%**	**4%**	**5%**	**3%**	**8%**	**3%**	**5%**	**4%**	**0%**	**6%**	**5%**	**8%**	**13%**	**5%**
Max RSD	**13%**	**13%**	**6%**	**8%**	**10%**	**20%**	**7%**	**7%**	**16%**	**7%**	**6%**	**9%**	**5%**	**14%**	**5%**	**10%**	**6%**	**0%**	**11%**	**10%**	**17%**	**42%**	**9%**

Sample	Ta	Tb	Th	Ti	Tm	U	V	W	Y	Yb	Zn	Zr
	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
130-1-180um	0.6	0.4	6.9	0.274	0.2	0.6	40	0.5	11.7	1.1	45	59.1
130-1-180um	0.5	0.4	7.3	0.272	0.2	0.7	42	0.6	11.5	1.2	44.9	62.1
Ave	0.55	0.4	7.1	0.273	0.2	0.65	41	0.55	11.6	1.15	45	60.6
RSD	13%	0%	4%	1%	0%	11%	3%	13%	1%	6%	0%	4%
114-2-180um	0.4	0.2	4.4	0.209	0.1	0.4	36	0.5	6.4	0.7	20.5	39.7
114-2-180um	0.4	0.2	3.9	0.182	0.1	0.4	33	0.4	5.9	0.7	20	34.9
Ave	0.4	0.2	4.15	0.196	0.1	0.4	34.5	0.45	6.15	0.7	20.3	37.3
RSD	0%	0%	9%	10%	0%	0%	6%	16%	6%	0%	2%	9%
105-1-75um	1.2	0.8	15.2	0.558	0.4	1.6	100	1.3	25.1	3.1	85.4	136.9
105-1-75um	1.2	0.7	14.3	0.56	0.4	1.5	93	1.3	25.5	2.7	83.9	134.1
Ave	1.2	0.75	14.8	0.559	0.4	1.55	96.5	1.3	25.3	2.9	84.7	135.5
RSD	0%	9%	4%	0%	0%	5%	5%	0%	1%	10%	1%	1%
131-1-75um	1.1	0.5	12.2	0.543	0.2	1.3	87	0.9	15.7	1.6	67.3	94.2
131-1-75um	1.1	0.6	11.8	0.542	0.2	1.3	82	0.9	14.9	1.6	63.5	93.3
Ave	1.1	0.55	12	0.543	0.2	1.3	84.5	0.9	15.3	1.6	65.4	93.75
RSD	0%	13%	2%	0%	0%	0%	4%	0%	4%	0%	4%	1%
133-2-75um	0.7	0.5	8.8	0.369	0.3	1	110	0.8	20.1	1.9	38.9	79.8
133-2-75um	0.7	0.5	9.5	0.373	0.3	1.1	127	1.1	22	2.1	42.6	89.5
Ave	0.7	0.5	9.15	0.371	0.3	1.05	119	0.95	21.1	2	40.8	84.65
RSD	0%	0%	5%	1%	0%	7%	10%	22%	6%	7%	6%	8%
Min RSD	**0%**	**0%**	**2%**	**0%**	**0%**	**0%**	**3%**	**0%**	**1%**	**0%**	**0%**	**1%**
Ave RSD	**3%**	**4%**	**5%**	**2%**	**0%**	**4%**	**6%**	**10%**	**4%**	**5%**	**3%**	**5%**
Max RSD	**13%**	**13%**	**9%**	**10%**	**0%**	**11%**	**10%**	**22%**	**6%**	**10%**	**6%**	**9%**

Appendix 3.3.2. GF-AAS analysis for Au (regolith)

Average and Relative Standard Deviation (RSD) shown in green below data.
(Relative Standard Deviation = 100 % x Standard Deviation / Average)
Numbers in red were reported as <LLD and are set to 0.5 LLD (Lower Limit of Detection)

Sample	SampleID	Au mg/kg
20058511081<75	20058511081<75	0.0004
DUP	20058511081<75	0.0005
Average		0.0005
RSD		16%
20058511181<180	20058511181<180	0.00005
DUP	20058511181<180	0.00005
Average		0.00005
RSD		0%
20058511312<180	20058511312<180	0.0001
DUP	20058511312<180	0.00005
Average		0.000075
RSD		47%
20058511362<180	20058511362<180	0.0005
DUP	20058511362<180	0.0005
Average		0.0005
RSD		0%
Min RSD		**0%**
Ave RSD		**16%**
Max RSD		**47%**

Note: Values <LLD have been halved (= 0.5 LLD)

Appendix 3.3.3. ISE analysis for F (regolith)

Average and Relative Standard Deviation (RSD) shown in green below data.
(Relative Standard Deviation = 100 % x Standard Deviation / Average)

Sample	SampleID	F mg/kg
2004851012002<180	2004851012002<180	390
DUP	2004851012002<180	360
Average		375
RSD		6%
2004851006002<75	2004851006002<75	300
DUP	2004851006002<75	320
Average		310
RSD		5%
2006031313	2004851006001<75	220
DUP	2004851006001<75	230
Average		225
RSD		3%
2006031314	GSD6	560
DUP	GSD6	560
Average		560
RSD		0%
20058511131<75	20058511131<75	220
DUP	20058511131<75	230
Average		225
RSD		3%
20058511152<75	20058511152<75	250
DUP	20058511152<75	250
Average		250
RSD		0%
20058511212<180	20058511212<180	160
DUP	20058511212<180	150
Average		155
RSD		5%
20058511241<180	20058511241<180	130
DUP	20058511241<180	130
Average		130
RSD		0%
20058511362<180	20058511362<180	370
DUP	20058511362<180	380
Average		375
RSD		2%
20058511432<180	20058511432<180	440
DUP	20058511432<180	430
Average		435
RSD		2%
Min RSD		**0%**
Ave RSD		**2%**
Max RSD		**6%**

Appendix 3.4. Lab standards

Appendix 3.4.1. ICP-MS analysis for multiple elements (regolith)

Minimum (Min), Average (Ave), Relative Standard Deviation (RSD) and maximum (Max) shown in green below data.
(Relative Standard Deviation = 100 % x Standard Deviation / Average)
Target Range (TR) defined in Table
Numbers in red were reported as <LLD and are set to 0.5 LLD (Lower Limit of Detection)

Sample	SampleID	Ag	Al	As	Au	Ba	Be	Bi	Ca	Cd	Ce	Co	Cr	Cs	Cu	Dy	Er	Eu
		ppb	%	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
	STANDARD DST6	323	6.99	24.3	0.05	692	3	4.57	2.28	5.75	57.15	13.7	232	8.8	128.27	2.9	1.5	0.9
	STANDARD DST6	326	6.90	23.9	0.05	687	3	4.83	2.27	5.56	60.11	13.5	235	8.5	129.66	2.9	1.7	1.1
	STANDARD DST6	324	7.03	24.2	0.05	688	4	4.84	2.30	5.70	60.69	14.2	226	8.8	130.92	2.9	1.5	1.0
	STANDARD DST6	323	6.95	26.3	0.05	713	3	4.86	2.28	5.86	59.11	14.1	237	8.6	131.55	2.9	1.5	1.0
	STANDARD DST6	309	6.94	23.2	0.05	692	3	4.88	2.28	5.26	50.98	14.1	231	8.7	130.18	2.8	1.5	0.9
Min		**309**	**6.90**	**23.2**	**0.05**	**687**	**3**	**4.57**	**2.27**	**5.26**	**50.98**	**13.5**	**226**	**8.5**	**128.27**	**2.8**	**1.5**	**0.9**
Ave		321	6.96	24.4	0.05	694	3	4.80	2.28	5.63	57.61	13.9	232	8.7	130.12	2.9	1.5	1.0
RSD		2%	1%	5%	0%	2%	14%	3%	0%	4%	7%	2%	2%	2%	1%	2%	6%	9%
Max		**326**	**7.03**	**26.3**	**0.05**	**713**	**4**	**4.88**	**2.30**	**5.86**	**60.69**	**14.2**	**237**	**8.8**	**131.55**	**2.9**	**1.7**	**1.1**
Official Value		365	6.92	24.3	<1	702	3.3	4.70	2.26	5.60	52.00	13.7	230	8.4	129.70	2.9	1.6	1.0
Target Range-Min	Official Value - 10%	**329**	**6.23**	**21.9**	**<1**	**632**	**3.0**	**4.23**	**2.03**	**5.04**	**46.80**	**12.3**	**207**	**7.6**	**116.73**	**2.6**	**1.4**	**0.9**
Target Range-Max	Official Value + 10%	**402**	**7.61**	**26.7**	**<1**	**772**	**3.6**	**5.17**	**2.49**	**6.16**	**57.20**	**15.1**	**253**	**9.2**	**142.67**	**3.2**	**1.8**	**1.1**
Replicates > TR Min?		No	Yes	Yes	N/A	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Replicates < TR Max?		Max < TR Min	Yes	Yes	N/A	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ave WRT Official Value		-12%	1%	0%	N/A	-1%	-3%	2%	1%	0%	11%	2%	1%	3%	0%	-1%	-4%	-2%

Note: Values <LLD have been halved (= 0.5 LLD)

Sample	Fe	Ga	Gd	Hf	Ho	K	La	Li	Lu	Mg	Mn	Mo	Na	Nb	Nd	Ni	P	Pb	Pr	Rb	S
	%	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	%	ppm	ppm	%	ppm	ppm	ppm	%	ppm	ppm	ppm	%
	4.09	17.43	3.6	1.94	0.6	1.38	25.5	27.2	0.2	1.00	966	12.53	1.633	8.45	23.0	29.4	0.099	36.4	5.6	57.2	0.02
	4.07	16.23	3.7	1.79	0.6	1.40	25.9	26.4	0.2	0.99	961	12.60	1.627	8.48	23.4	29.7	0.099	37.76	6.5	61.4	0.02
	4.08	16.83	3.5	1.89	0.6	1.38	25.5	26.7	0.2	1.00	965	12.65	1.631	9.02	23.0	30.4	0.097	36.24	5.7	58.8	0.02
	4.07	17.30	4.2	1.80	0.5	1.37	25.7	27.2	0.2	0.99	964	12.74	1.626	8.42	23.1	30.2	0.098	35.09	5.6	59.9	0.02
	4.08	18.02	3.6	1.95	0.5	1.41	22.1	29.1	0.2	0.99	963	12.68	1.632	9.55	21.7	30.2	0.100	37.03	5.3	61.9	0.02
Min	**4.07**	**16.23**	**3.5**	**1.79**	**0.5**	**1.37**	**22.1**	**26.4**	**0.2**	**0.99**	**961**	**12.53**	**1.626**	**8.42**	**21.7**	**29.4**	**0.097**	**35.09**	**5.3**	**57.2**	**0.02**
Ave	4.08	17.16	3.7	1.87	0.6	1.39	24.9	27.3	0.2	0.99	964	12.64	1.630	8.78	22.8	30.0	0.099	36.50	5.7	59.8	0.02
RSD	0%	4%	7%	4%	10%	1%	6%	4%	0%	1%	0%	1%	0%	6%	3%	1%	1%	3%	8%	3%	0%
Max	**4.09**	**18.02**	**4.2**	**1.95**	**0.6**	**1.41**	**25.9**	**29.1**	**0.2**	**1.00**	**966**	**12.74**	**1.633**	**9.55**	**23.4**	**30.4**	**0.100**	**37.76**	**6.5**	**61.9**	**0.02**
Official Value	3.91	16.10	3.6	1.80	0.5	1.42	25.7	25.4	0.2	1.03	980	12.70	1.673	8.11	23.0	30.4	0.099	36.70	5.4	61.2	<0.04
Target Range-Min	**3.52**	**14.49**	**3.2**	**1.62**	**0.5**	**1.28**	**23.1**	**22.9**	**0.2**	**0.93**	**882**	**11.43**	**1.506**	**7.30**	**20.7**	**27.4**	**0.089**	**33.03**	**4.9**	**55.1**	**<0.04**
Target Range-Max	**4.30**	**17.71**	**4.0**	**1.98**	**0.6**	**1.56**	**28.3**	**27.9**	**0.2**	**1.13**	**1078**	**13.97**	**1.840**	**8.92**	**25.3**	**33.4**	**0.109**	**40.37**	**5.9**	**67.3**	**<0.04**
Replicates > TR Min?	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	N/A
Replicates < TR Max?	Yes	No	No	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	N/A
Ave WRT Official Value	4%	7%	3%	4%	12%	-2%	-3%	8%	0%	-3%	-2%	0%	-3%	8%	-1%	-1%	0%	-1%	6%	-2%	N/A

Sample	Sb	Sc	Sm	Sn	Sr	Ta	Tb	Th	Ti	Tm	U	V	W	Y	Yb	Zn	Zr
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
	5.58	12.0	4.4	6.2	316	0.8	0.5	7.3	0.395	0.2	7.9	113	8	15.4	1.6	171.4	58.3
	5.48	11.2	4.5	6.3	318	0.8	0.5	7.7	0.417	0.2	8.4	112	7.5	15.7	1.6	174.7	56.9
	5.67	12.2	4.4	6.6	309	0.9	0.5	7.2	0.395	0.2	7.7	111	7.3	15.5	1.6	173.8	60.9
	5.50	12.9	4.5	6.7	323	0.8	0.5	7.3	0.405	0.2	8.0	111	7.8	15.6	1.5	175.5	58.5
	5.63	10.8	3.8	6.5	313	0.7	0.5	6.9	0.396	0.2	7.7	114	7.6	15.0	1.6	178.6	58.9
Min	**5.48**	**10.8**	**3.8**	**6.2**	**309**	**0.7**	**0.5**	**6.9**	**0.395**	**0.2**	**7.7**	**111**	**7.3**	**15.0**	**1.5**	**171.4**	**56.9**
Ave	5.57	11.8	4.3	6.5	316	0.8	0.5	7.3	0.402	0.2	7.9	112	7.6	15.4	1.6	174.8	58.7
RSD	1%	7%	7%	3%	2%	9%	0%	4%	2%	0%	4%	1%	4%	2%	3%	2%	2%
Max	**5.67**	**12.9**	**4.5**	**6.7**	**323**	**0.9**	**0.5**	**7.7**	**0.417**	**0.2**	**8.4**	**114**	**8.0**	**15.7**	**1.6**	**178.6**	**60.9**
Official Value	5.39	10.1	4.5	6.3	298	0.6	0.5	6.9	0.387	0.2	7.8	115	7.4	15.2	1.6	176.0	50.1
Target Range-Min	**4.85**	**9.1**	**4.1**	**5.7**	**268**	**0.5**	**0.5**	**6.2**	**0.348**	**0.2**	**7.0**	**104**	**6.7**	**13.7**	**1.4**	**158.4**	**45.1**
Target Range-Max	**5.93**	**11.1**	**5.0**	**6.9**	**328**	**0.7**	**0.6**	**7.6**	**0.426**	**0.2**	**8.6**	**127**	**8.1**	**16.7**	**1.8**	**193.6**	**55.1**
Replicates > TR Min?	Yes	Yes	No	Yes	Yes	Min > TR Max	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Min > TR Max
Replicates < TR Max?	Yes	No	Yes	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Ave WRT Official Value	3%	17%	-4%	3%	6%	33%	0%	6%	4%	0%	2%	-2%	3%	2%	-1%	-1%	17%

Appendix 3.4.2. GF-AAS analysis for Au (regolith)

Minimum (Min), Average (Ave), Relative Standard Deviation (RSD) and maximum (Max) shown in green below data.
(Relative Standard Deviation = 100 % x Standard Deviation / Average)
Target Value calculated as average of Target Range (TR) Min and TR Max provided by laboratory

SAMPLE	SAMPLEID	Au ppm
LIQSTD24-BR06021395	LIQSTD24	0.0416
LIQSTD24-BR06000519	LIQSTD24	0.0408
LIQSTD24-BR06000519	LIQSTD24	0.0439
LIQSTD24-BR06000519	LIQSTD24	0.0406
LIQSTD24-BR06000519	LIQSTD24	0.0404
LIQSTD24-BR06000519	LIQSTD24	0.0450
Min		**0.0404**
Ave		0.0421
RSD		5%
Max		**0.0450**
Target Value		0.0400
Target Range-Min		**0.0349**
Target Range-Max		**0.0451**
Replicates > TR Min?		Yes
Replicates < TR Max?		Yes
Ave WRT Target Value		+5%
ST252-BR06021395	ST252	0.0510
ST252-BR06000519	ST252	0.0530
ST252-BR06000519	ST252	0.0550
Min		**0.0510**
Ave		0.0530
RSD		4%
Max		**0.0550**
Target Value		0.0525
Target Range-Min		**0.0458**
Target Range-Max		**0.0592**
Replicates > TR Min?		Yes
Replicates < TR Max?		Yes
Ave WRT Target Value		+1%
ST299-BR06021395	ST299	0.0073
ST299-BR06000519	ST299	0.0077
ST299-BR06000519	ST299	0.0077
ST299-BR06000519	ST299	0.0056
Min		**0.0056**
Ave		0.0071
RSD		14%
Max		**0.0077**
Target Value		0.0065
Target Range-Min		**0.0056**
Target Range-Max		**0.0074**
Replicates > TR Min?		Yes
Replicates < TR Max?		No
Ave WRT Target Value		+9%

Appendix 3.5. Blind standards

Appendix 3.5.1. ICP-MS analysis for multiple elements (regolith)

Minimum (Min), Average (Ave), Relative Standard Deviation (RSD) and maximum (Max) shown in green below data.
(Relative Standard Deviation = 100 % x Standard Deviation / Average)
Target Range (TR) defined in Table
Numbers in red were reported as <LLD and are set to 0.5 LLD (Lower Limit of Detection), and in the case of W values >ULD are set to 2 ULD (Upper Limit of Detection)

SAMPLE	SAMPLEID	Ag	Al	As	Au	Ba	Be	Bi	Ca	Cd	Ce
		ppb	%	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm
GA9	144-1-75um	10	6.22	2.3	0.05	621	4	0.16	0.56	0.07	125.94
GA9	146-1-75um	10	6.35	1.6	0.05	575	3	0.15	0.53	0.06	113.36
Min		**10**	**6.22**	**1.6**	**0.05**	**575**	**3**	**0.15**	**0.53**	**0.06**	**113.36**
Ave		10	6.29	2.0	0.05	598	4	0.16	0.55	0.07	119.65
RSD		0%	1%	25%	0%	5%	20%	5%	4%	11%	7%
Max		**10**	**6.35**	**2.3**	**0.05**	**621**	**4**	**0.16**	**0.56**	**0.07**	**125.94**
Target Value*		170		1.0		567	3	0.37		0.03	105.55
Target Range-Min	Target Value - 10%	**153**		**0.9**		**510**	**3**	**0.33**		**0.03**	**94.99**
Target Range-Max	Target Value + 10%	**187**		**1.1**		**624**	**4**	**0.40**		**0.03**	**116.10**
Replicates > TR Min?		No		Min > TR Max		Yes	Yes	No		Min > TR Max	Yes
Replicates < TR Max?		Max < TR Min		No		Yes	No	Max < TR Min		No	No
Ave WRT Target Value		-94%		+104%		+5%	+7%	-58%		+109%	+13%
GA25	145-1-75um	10	8.70	2.7	0.05	1105	2	0.04	5.27	0.25	106.83
GA25	147-1-75um	10	9.13	2.6	0.05	1144	2	0.02	5.37	0.32	104.71
Min		**10**	**8.70**	**2.6**	**0.05**	**1105**	**2**	**0.02**	**5.27**	**0.25**	**104.71**
Ave		10	8.92	2.7	0.05	1125	2	0.03	5.32	0.29	105.77
RSD		0%	3%	3%	0%	2%	0%	47%	1%	17%	1%
Max		**10**	**9.13**	**2.7**	**0.05**	**1144**	**2**	**0.04**	**5.37**	**0.32**	**106.83**
Target Value*		110		0.4		1126	2	0.46		0.16	96.11
Target Range-Min	Target Value - 10%	**99**		**0.4**		**1013**	**2**	**0.42**		**0.15**	**86.50**
Target Range-Max	Target Value + 10%	**121**		**0.5**		**1238**	**2**	**0.51**		**0.18**	**105.72**
Replicates > TR Min?		No		Min > TR Max		Yes	Yes	No		Min > TR Max	Yes
Replicates < TR Max?		Max < TR Min		No		Yes	Yes	Max < TR Min		No	No
Ave WRT Target Value		-91%		+541%		-0%	+6%	-93%		+76%	+10%
* Method for Target Value determination (GA)		ICP-MS		XRF		ICP-MS	ICP-MS	ICP-MS		ICP-MS	ICP-MS

Note: Values <LLD have been halved (= 0.5 LLD); Values >ULD have been doubled (= 2 ULD) (latter only for W)

SAMPLE	Co	Cr	Cs	Cu	Dy	Er	Eu	Fe	Ga	Gd	Hf	Ho	K
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	%
GA9	27.5	61	2.9	10.07	14.2	9.6	1.2	1.61	20.71	13.5	4.92	3.4	3.45
GA9	26.6	56	2.7	9.53	13.0	8.1	1.2	1.53	18.69	11.7	4.16	2.8	3.59
Min	**26.6**	**56**	**2.7**	**9.53**	**13.0**	**8.1**	**1.2**	**1.53**	**18.69**	**11.7**	**4.16**	**2.8**	**3.45**
Ave	27.1	59	2.8	9.80	13.6	8.9	1.2	1.57	19.70	12.6	4.54	3.1	3.52
RSD	2%	6%	5%	4%	6%	12%	0%	4%	7%	10%	12%	14%	3%
Max	**27.5**	**61**	**2.9**	**10.07**	**14.2**	**9.6**	**1.2**	**1.61**	**20.71**	**13.5**	**4.92**	**3.4**	**3.59**
Target Value*	25.4	74	2.5	12.36	13.9	9.1	1.3		17.91	11.8	7.15	3.1	
Target Range-Min	**22.9**	**66**	**2.3**	**11.12**	**12.5**	**8.2**	**1.1**		**16.12**	**10.6**	**6.44**	**2.8**	
Target Range-Max	**27.9**	**81**	**2.8**	**13.59**	**15.3**	**10.0**	**1.4**		**19.70**	**12.9**	**7.87**	**3.4**	
Replicates > TR Min?	Yes	No	Yes	No	Yes	No	Yes		Yes	Yes	No	No	
Replicates < TR Max?	Yes	Max < TR Min	No	Max < TR Min	Yes	Yes	Yes		No	No	Max < TR Min	Yes	
Ave WRT Target Value	+6%	-20%	+11%	-21%	-2%	-3%	-5%		+10%	+7%	-37%	-0%	
GA25	49.5	95	1.4	47.86	3.5	1.9	2.5	9.08	15.97	5.1	3.85	0.8	1.91
GA25	49.6	92	1.6	44.27	3.8	2.0	2.4	9.20	15.68	5.6	3.79	0.8	1.96
Min	**49.5**	**92**	**1.4**	**44.27**	**3.5**	**1.9**	**2.4**	**9.08**	**15.68**	**5.1**	**3.79**	**0.8**	**1.91**
Ave	49.6	94	1.5	46.07	3.7	2.0	2.5	9.14	15.83	5.4	3.82	0.8	1.94
RSD	0%	2%	9%	6%	6%	4%	3%	1%	1%	7%	1%	0%	2%
Max	**49.6**	**95**	**1.6**	**47.86**	**3.8**	**2.0**	**2.5**	**9.20**	**15.97**	**5.6**	**3.85**	**0.8**	**1.96**
Target Value*	49.3	99	1.4	51.73	3.9	2.0	2.3		15.18	5.0	3.55	0.8	
Target Range-Min	**44.4**	**89**	**1.2**	**46.56**	**3.6**	**1.8**	**2.1**		**13.66**	**4.5**	**3.20**	**0.7**	
Target Range-Max	**54.3**	**109**	**1.5**	**56.90**	**4.3**	**2.2**	**2.6**		**16.70**	**5.5**	**3.91**	**0.8**	
Replicates > TR Min?	Yes	Yes	Yes	No	No	Yes	Yes		Yes	Yes	Yes	Yes	
Replicates < TR Max?	Yes	Yes	No	Yes	Yes	Yes	Yes		Yes	No	Yes	Yes	
Ave WRT Target Value	+0%	-5%	+9%	-11%	-8%	-4%	+5%		+4%	+6%	+8%	+4%	

* Method for Target Value	ICP-MS	XRF	ICP-MS	XRF	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS

SAMPLE	La	Li	Lu	Mg	Mn	Mo	Na	Nb	Nd	Ni	P	Pb	Pr	Rb	S
	ppm	ppm	ppm	%	ppm	ppm	%	ppm	ppm	ppm	%	ppm	ppm	ppm	%
GA9	51.2	12.6	1.4	0.07	253	1.13	2.545	12.55	57.6	106.8	0.010	23.29	13.6	197.8	0.02
GA9	47.3	11.7	1.3	0.07	244	1.01	2.540	11.94	50.0	110.4	0.011	21.96	12.1	180.1	0.02
Min	**47.3**	**11.7**	**1.3**	**0.07**	**244**	**1.01**	**2.540**	**11.94**	**50.0**	**106.8**	**0.010**	**21.96**	**12.1**	**180.1**	**0.02**
Ave	49.3	12.2	1.4	0.07	249	1.07	2.543	12.25	53.8	108.6	0.011	22.63	12.9	189.0	0.02
RSD	6%	5%	5%	0%	3%	8%	0%	4%	10%	2%	7%	4%	8%	7%	0%
Max	**51.2**	**12.6**	**1.4**	**0**	**253**	**1.13**	**2.545**	**12.55**	**57.6**	**110.4**	**0.011**	**23.29**	**13.6**	**197.8**	**0.02**
Target Value*	50.8		1.3			1.07		12.07	51.3	79.3		22.04	13.5	198.5	
Target Range-Min	**45.7**		**1.2**			**0.96**		**10.86**	**46.1**	**71.4**		**19.84**	**12.2**	**178.6**	
Target Range-Max	**55.9**		**1.5**			**1.17**		**13.27**	**56.4**	**87.2**		**24.25**	**14.9**	**218.3**	
Replicates > TR Min?	Yes		Yes			Yes		Yes	Yes	Min > TR Max		Yes	No	Yes	
Replicates < TR Max?	Yes		Yes			Yes		Yes	No	No		Yes	Yes	Yes	
Ave WRT Target Value	-3%		+1%			+0%		+1%	+5%	+37%		+3%	-5%	-5%	
GA25	52.6	10.8	0.2	2.77	1646	2.18	3.146	90.74	37.5	50.1	0.297	8.48	10.1	78.0	0.08
GA25	51.0	11.5	0.3	2.89	1706	2.10	3.190	89.52	38.6	51.2	0.292	8.07	9.9	83.0	0.08
Min	**51.0**	**10.8**	**0.2**	**2.77**	**1646**	**2.10**	**3.146**	**89.52**	**37.5**	**50.1**	**0.292**	**8.07**	**9.9**	**78.0**	**0.08**
Ave	51.8	11.2	0.3	2.83	1676	2.14	3.168	90.13	38.1	50.7	0.295	8.28	10.0	80.5	0.08
RSD	2%	4%	28%	3%	3%	3%	1%	1%	2%	2%	1%	4%	1%	4%	0%
Max	**52.6**	**11.5**	**0.3**	**2.89**	**1706**	**2.18**	**3.190**	**90.74**	**38.6**	**51.2**	**0.297**	**8.48**	**10.1**	**83.0**	**0.08**
Target Value*	53.7		0.3			1.91		87.04	37.5	63.3		7.33	10.4	85.5	
Target Range-Min	**48.3**		**0.2**			**1.72**		**78.33**	**33.8**	**57.0**		**6.60**	**9.3**	**76.9**	
Target Range-Max	**59.1**		**0.3**			**2.11**		**95.74**	**41.3**	**69.7**		**8.07**	**11.4**	**94.0**	
Replicates > TR Min?	Yes		No			Yes		Yes	Yes	No		Min > TR Max	Yes	Yes	
Replicates < TR Max?	Yes		No			No		Yes	Yes	Max < TR Min		No	Yes	Yes	
Ave WRT Target Value	-4%		-2%			+12%		+4%	+1%	-20%		+13%	-3%	-6%	

* Method for Target Value	ICP-MS		ICP-MS			ICP-MS		ICP-MS	ICP-MS	XRF		ICP-MS	ICP-MS	ICP-MS	

SAMPLE	Sb	Sc	Sm	Sn	Sr	Ta	Tb	Th	Ti	Tm	U
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm
GA9	0.28	5.8	12.3	5.8	38	1.9	2.4	27.5	0.118	1.4	6.2
GA9	0.24	6.0	11.1	5.0	39	1.7	2.2	26.2	0.118	1.2	5.7
Min	**0.24**	**5.8**	**11.1**	**5.0**	**38**	**1.7**	**2.2**	**26.2**	**0.118**	**1.2**	**5.7**
Ave	0.26	5.9	11.7	5.4	39	1.8	2.3	26.9	0.118	1.3	6.0
RSD	11%	2%	7%	10%	2%	8%	6%	3%	0%	11%	6%
Max	**0.28**	**6.0**	**12.3**	**5.8**	**39**	**1.9**	**2.4**	**27.5**	**0.118**	**1.4**	**6.2**
Target Value*	0.44	6.8	12.3	5.3	32	1.1	2.3	24.7			5.4
Target Range-Min	**0.40**	**6.1**	**11.1**	**4.8**	**29**	**1.0**	**2.1**	**22.2**			**4.8**
Target Range-Max	**0.48**	**7.4**	**13.5**	**5.9**	**36**	**1.2**	**2.6**	**27.2**			**5.9**
Replicates > TR Min?	No	No	Yes	Yes	Min > TR Max	Min > TR Max	Yes	Yes			Yes
Replicates < TR Max?	Max < TR Min	Max < TR Min	Yes	Yes	No	No	Yes	No			No
Ave WRT Target Value	-41%	-13%	-5%	+1%	+19%	+63%	-2%	+9%			+10%
GA25	0.06	13.9	6.6	1.4	1409	7.0	0.8	8.5	1.644	0.3	1.6
GA25	0.06	14.1	6.3	1.4	1381	6.8	0.7	9.1	1.636	0.3	1.6
Min	**0.06**	**13.9**	**6.3**	**1.4**	**1381**	**6.8**	**0.7**	**8.5**	**1.636**	**0.3**	**1.6**
Ave	0.06	14.0	6.5	1.4	1395	6.9	0.8	8.8	1.640	0.3	1.6
RSD	0%	1%	3%	0%	1%	2%	9%	5%	0%	0%	0%
Max	**0.06**	**14.1**	**6.6**	**1.4**	**1409**	**7.0**	**0.8**	**9.1**	**1.644**	**0.3**	**1.6**
Target Value*	0.28	14.5	6.7	1.3	1228	4.7	0.8	7.7			1.4
Target Range-Min	**0.25**	**13.1**	**6.1**	**1.2**	**1106**	**4.2**	**0.7**	**7.0**			**1.3**
Target Range-Max	**0.31**	**16.0**	**7.4**	**1.4**	**1351**	**5.1**	**0.8**	**8.5**			**1.6**
Replicates > TR Min?	No	Yes	Yes	Yes	Min > TR Max	Min > TR Max	Yes	Yes			Min > TR Max
Replicates < TR Max?	Max < TR Min	Yes	Yes	Yes	No	No	Yes	No			No
Ave WRT Target Value	-79%	-4%	-4%	+7%	+14%	+47%	-1%	+14%			+12%
* Method for Target Value	ICP-MS	XRF	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS			ICP-MS

SAMPLE	V	W	Y	Yb	Zn	Zr
	ppm	ppm	ppm	ppm	ppm	ppm
GA9	3	400.0	85.4	8.7	45.6	97.8
GA9	3	196.6	79.9	7.9	39.1	91.7
Min	**3**	**196.6**	**79.9**	**7.9**	**39.1**	**91.7**
Ave	3	298.3	82.7	8.3	42.4	94.8
RSD	0%	48%	5%	7%	11%	5%
Max	**3**	**400.0**	**85.4**	**8.7**	**45.6**	**97.8**
Target Value*	4		91.8	8.5	35.4	204.7
Target Range-Min	**3**		**82.6**	**7.6**	**31.8**	**184.2**
Target Range-Max	**4**		**101.0**	**9.3**	**38.9**	**225.1**
Replicates > TR Min?	No		No	Yes	Min > TR Max	No
Replicates < TR Max?	Max < TR Min		Yes	Yes	No	Max < TR Min
Ave WRT Target Value	-15%		-10%	-2%	+20%	-54%
GA25	176	51.8	19.5	1.9	75.9	158.3
GA25	169	51.6	19.1	1.8	80.7	158.8
Min	**169**	**51.6**	**19.1**	**1.8**	**75.9**	**158.3**
Ave	173	51.7	19.3	1.9	78.3	158.6
RSD	3%	0%	1%	4%	4%	0%
Max	**176**	**51.8**	**19.5**	**1.9**	**80.7**	**158.8**
Target Value*	161		20.8	1.7	75.0	159.3
Target Range-Min	**145**		**18.7**	**1.5**	**67.5**	**143.4**
Target Range-Max	**178**		**22.9**	**1.8**	**82.5**	**175.3**
Replicates > TR Min?	Yes		Yes	Yes	Yes	Yes
Replicates < TR Max?	Yes		Yes	No	Yes	Yes
Ave WRT Target Value	+7%		-7%	+12%	+4%	-0%
* Method for Target Value	XRF		ICP-MS	ICP-MS	XRF	ICP-MS

Appendix 3.5.2. ISE analysis for F (regolith)

See Caritat and Lech (2007) for more QA data for F using the same laboratory

SAMPLE	SAMPLEID	F
		mg/kg
GSD6	2006031314	560
Target Value		690
Reported value WRT Target Value		-19%

Appendix 3.5.3. ICP-MS analysis for Se (regolith)

Minimum (Min), Average (Ave), Relative Standard Deviation (RSD) and maximum (Max) shown in green below data.
(Relative Standard Deviation = 100 % x Standard Deviation / Average)
Target Range (TR) defined in Table

See Caritat and Lech (2007) for more QA data for Se using the same laboratory

Sample	SampleID	Se mg/kg
A2	GSD6	0.349
B2	GSD6	0.333
Min		**0.333**
Ave		0.341
RSD		3%
Max		**0.349**
Target Value		0.300
Target Range-Min	Target Value - 10%	**0.270**
Target Range-Max	Target Value + 10%	**0.330**
Replicates > TR Min?		Min > TR Max
Replicates < TR Max?		No
Ave WRT Target Value		+14%
C3	GSD3	1.011
D3	GSD3	1.010
Min		**1.010**
Ave		1.010
RSD		0%
Max		**1.011**
Target Value		1.060
Target Range-Min	Target Value - 10%	**0.954**
Target Range-Max	Target Value + 10%	**1.166**
Replicates > TR Min?		Yes
Replicates < TR Max?		Yes
Ave WRT Target Value		-5%

Appendix 3.6. Blanks

Appendix 3.6.1. ICP-MS analysis for multiple elements (groundwater)

Filter blank: Milli-Q® water processed through filtering apparatus and acidified in the field
Travel blank: unfiltered Milli-Q® water acidified in the field (Sample ID '222FA' should read '222A')
Numbers in red were reported as <LLD and are set to 0.5 LLD (Lower Limit of Detection)

Sample			Filter blank	Travel blank
SampleID			221 FA	222 FA
	Ag	ug/L	0.5	0.5
	Al	ug/L	0.5	0.5
	As	ug/L	0.5	0.5
	B	ug/L	0.5	0.5
	Ba	ug/L	0.5	0.5
	Be	ug/L	0.5	0.5
	Bi	ug/L	0.5	0.5
	Cd	ug/L	0.5	0.5
	Ce	ug/L	0.5	0.5
	Co	ug/L	0.5	0.5
	Cr	ug/L	0.5	0.5
	Cs	ug/L	0.5	0.5
	Cu	ug/L	0.5	0.5
	Dy	ug/L	0.5	0.5
	Er	ug/L	0.5	0.5
	Eu	ug/L	0.5	0.5
	Fe	ug/L	0.5	0.5
	Ga	ug/L	0.5	0.5
	Gd	ug/L	0.5	0.5
	Gd	ug/L	0.5	0.5
	Ge	ug/L	0.5	0.5
	Hf	ug/L	0.5	0.5
	Ho	ug/L	0.5	0.5
	La	ug/L	0.5	0.5
	Li	ug/L	0.5	0.5
	Lu	ug/L	0.5	0.5
	Mn	ug/L	0.5	0.5
	Mo	ug/L	0.5	0.5
	Nb	ug/L	0.5	0.5
	Nd	ug/L	0.5	0.5
	Ni	ug/L	0.5	0.5
	Pb	ug/L	0.5	0.5
	Pr	ug/L	0.5	0.5
	Rb	ug/L	0.5	0.5
	Sb	ug/L	0.5	0.5
	Sc	ug/L	0.5	0.5
	Sm	ug/L	0.5	0.5
	Sn	ug/L	0.5	0.5
	Sr	ug/L	0.5	0.5
	Ta	ug/L	0.5	0.5
	Tb	ug/L	0.5	0.5
	Th	ug/L	0.5	0.5
	U	ug/L	0.5	0.5
	V	ug/L	0.5	0.5
	W	ug/L	0.5	0.5
	Y	ug/L	0.5	0.5
	Yb	ug/L	0.5	0.5
	Zn	ug/L	0.5	0.5
	Zr	ug/L	0.5	0.5

Note: Values <LLD have been halved (= 0.5 LLD)
FA: Filtered (0.45 um) and acidified (ultrapure HNO3)

11 APPENDIX 4. GEOCHEMICAL MAPS

Appendix 4.1. Regolith (TOS and BOS)

Parameter codes consist of:

(1) the element or parameter:

- Cy = Clay; St = Silt; Sd = Sand
- pH = pH, pH15 = pH 1:5 (soil:water) solution, EC15 = Electric Conductivity 1:5 (soil:water) solution
- Chemical symbol (Ag = silver, Al = aluminium, etc.)
- Fet = total iron
- LOIc = Calculated Loss on Ignition (see text)

(2) the analytical method (capital letter):

- A: Graphite furnace atomic adsorption spectrometry, Au (ALS Chemex Labs)
- C: Inductively coupled plasma-mass spectrometry, Se (CSIRO Labs)
- E: Electrode, EC15 (BRS Labs)
- F: Field analysis, soil pH kit
- I: Ion specific electrode, F (ALS Chemex Labs)
- L: Laser particle size analysis
- P: Potentiometry, pH15 (BRS Labs)
- T: Inductively coupled plasma-mass spectrometry (method 1T-MS, Acme Labs)
- X: X-ray fluorescence (GA Labs)
- Z: calculated (see text)

(3) the units (small letter):

- c: percent
- p: pH units (-log[H^+])
- m: parts per million
- u: microSiemens/centimeter

(4) the sample type (starts with a capital letter):

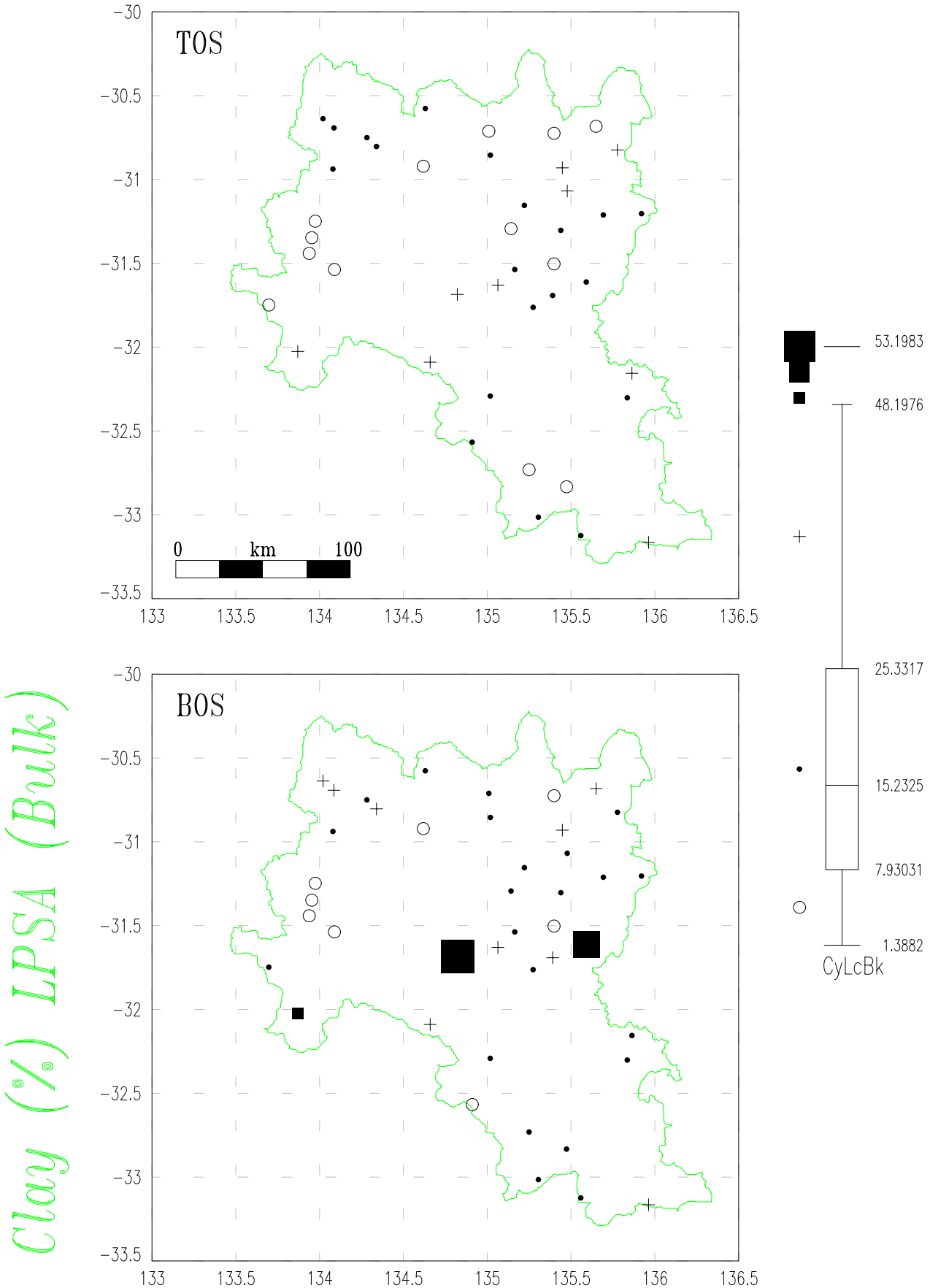
- Bk: Bulk
- 180: <180 um fraction
- 75: <75 um fraction
- 75180: ratio of (<75 um fraction/<180 um fraction)

All maps are shown for completeness, though certain preparation and analysis methods are more appropriate than others for specific elements. Direct comparisons, e.g., between ICP-MS results from GA Labs and Acme Labs, are therefore not warranted without full understanding of the differences between methods

Values reported as <LLD are set to 0.5 LLD (Lower Limit of Detection)

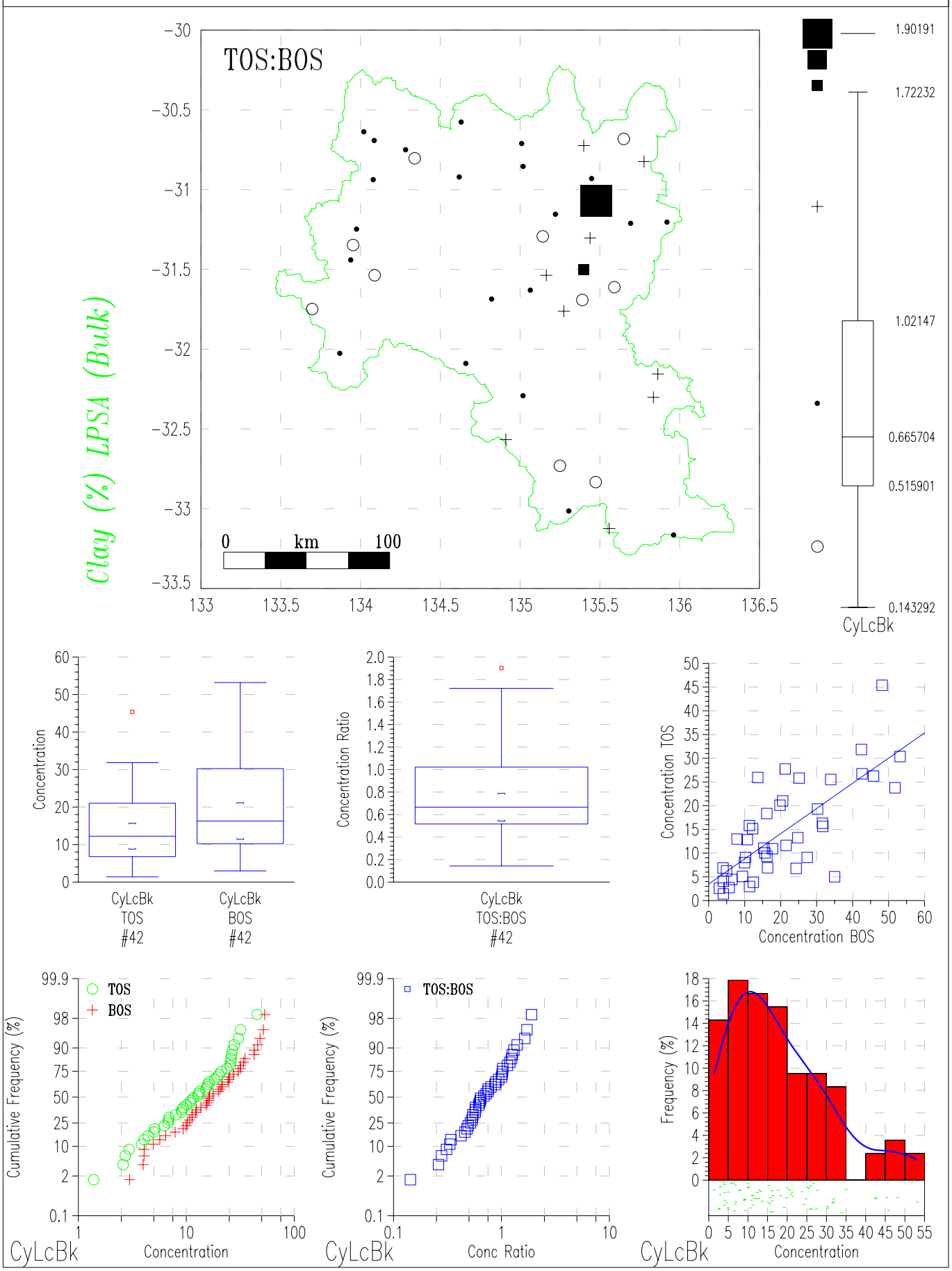
GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



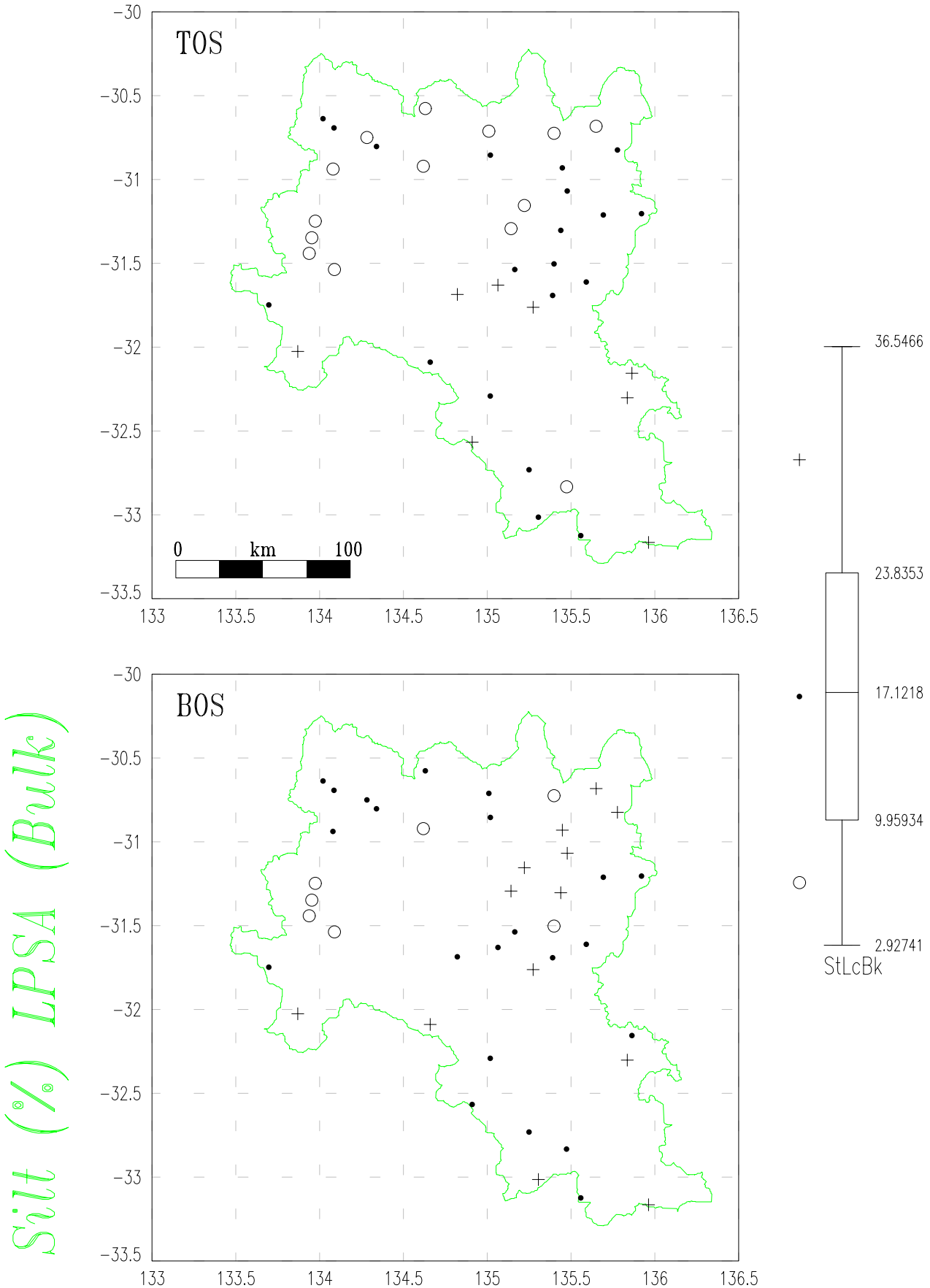
GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



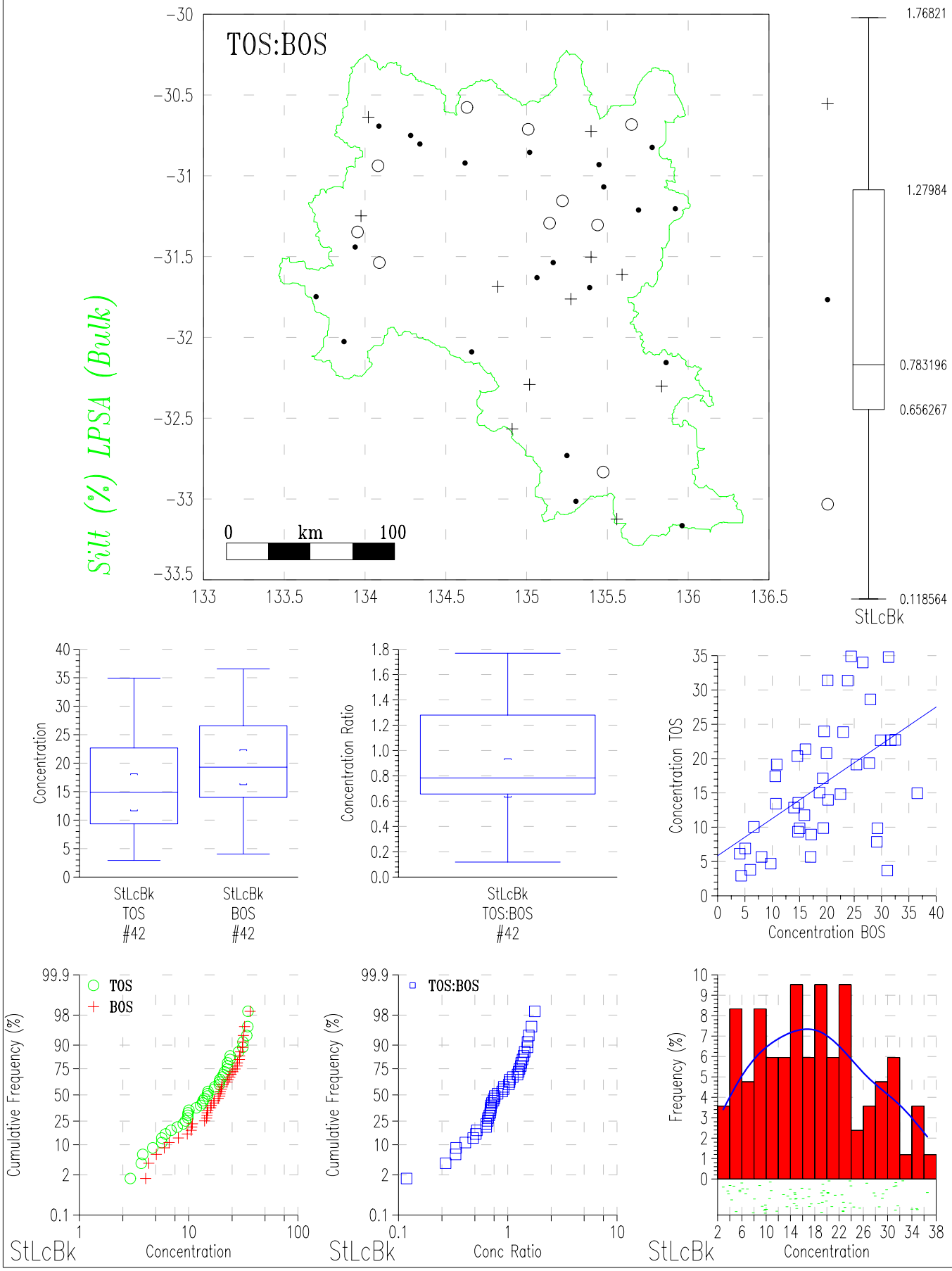
GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



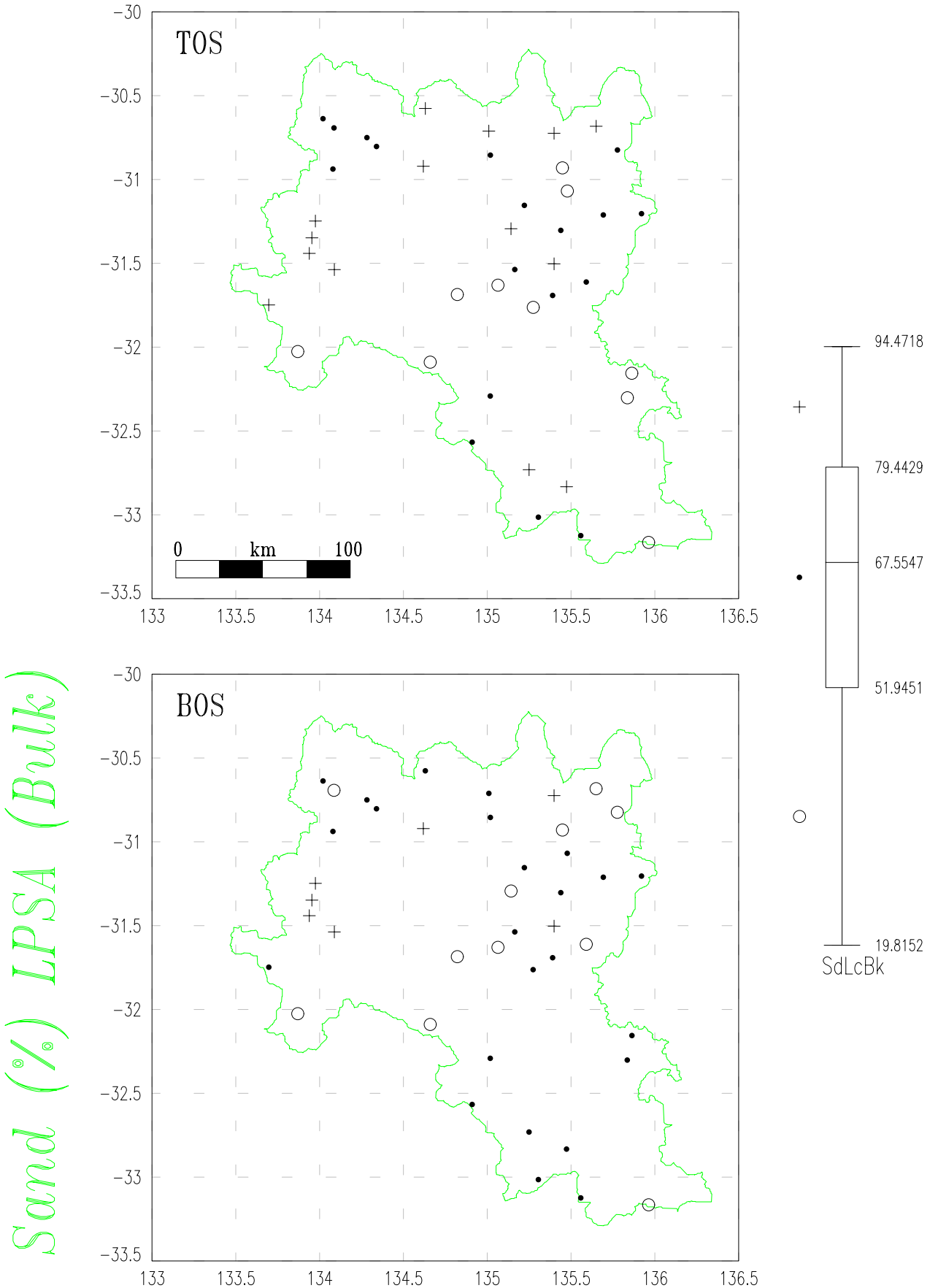
GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



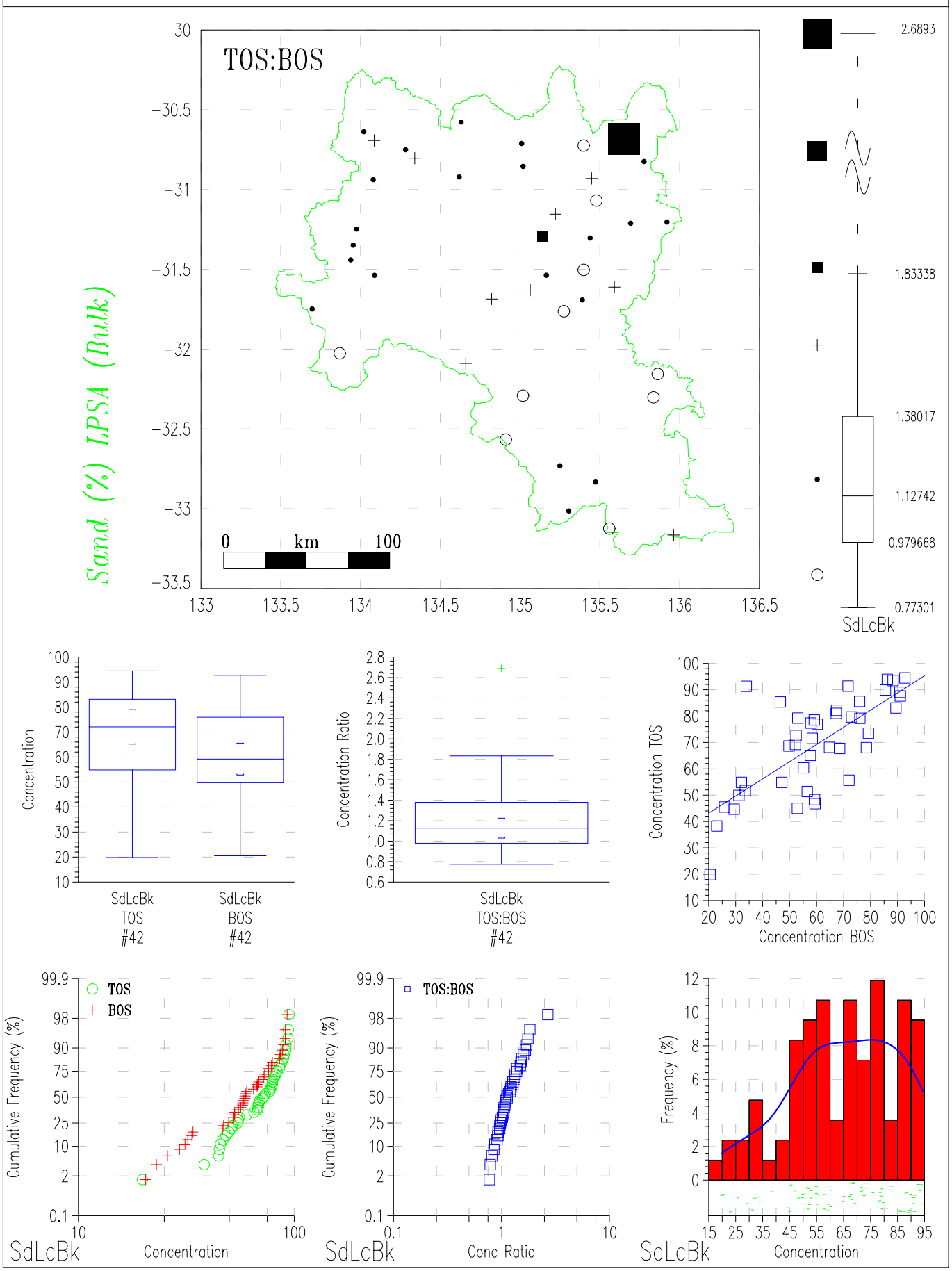
GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



GAWLER GEOCHEMICAL SURVEY

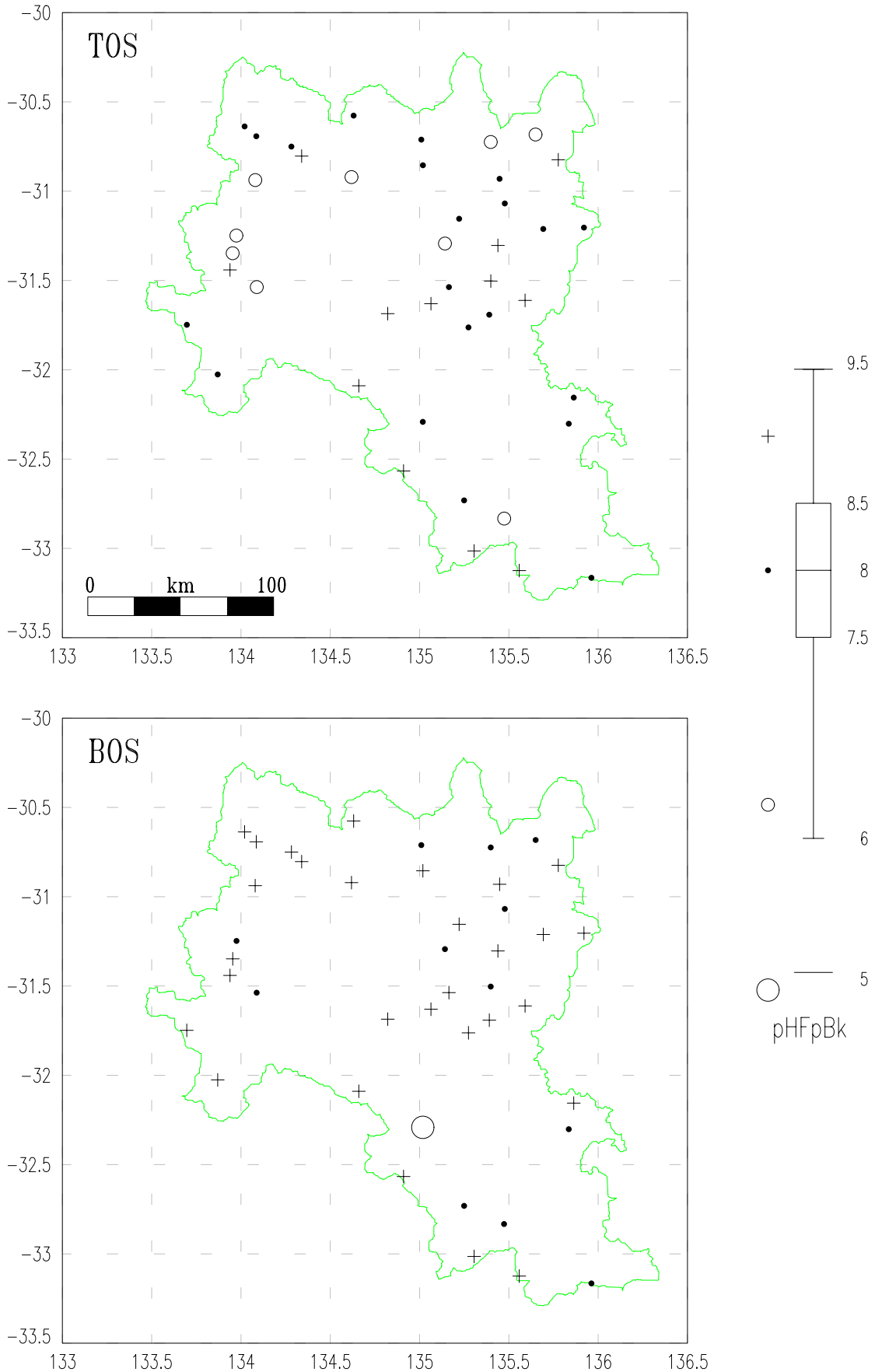
Top & Bottom Outlet Sediments (TOS & BOS)



GAWLER GEOCHEMICAL SURVEY

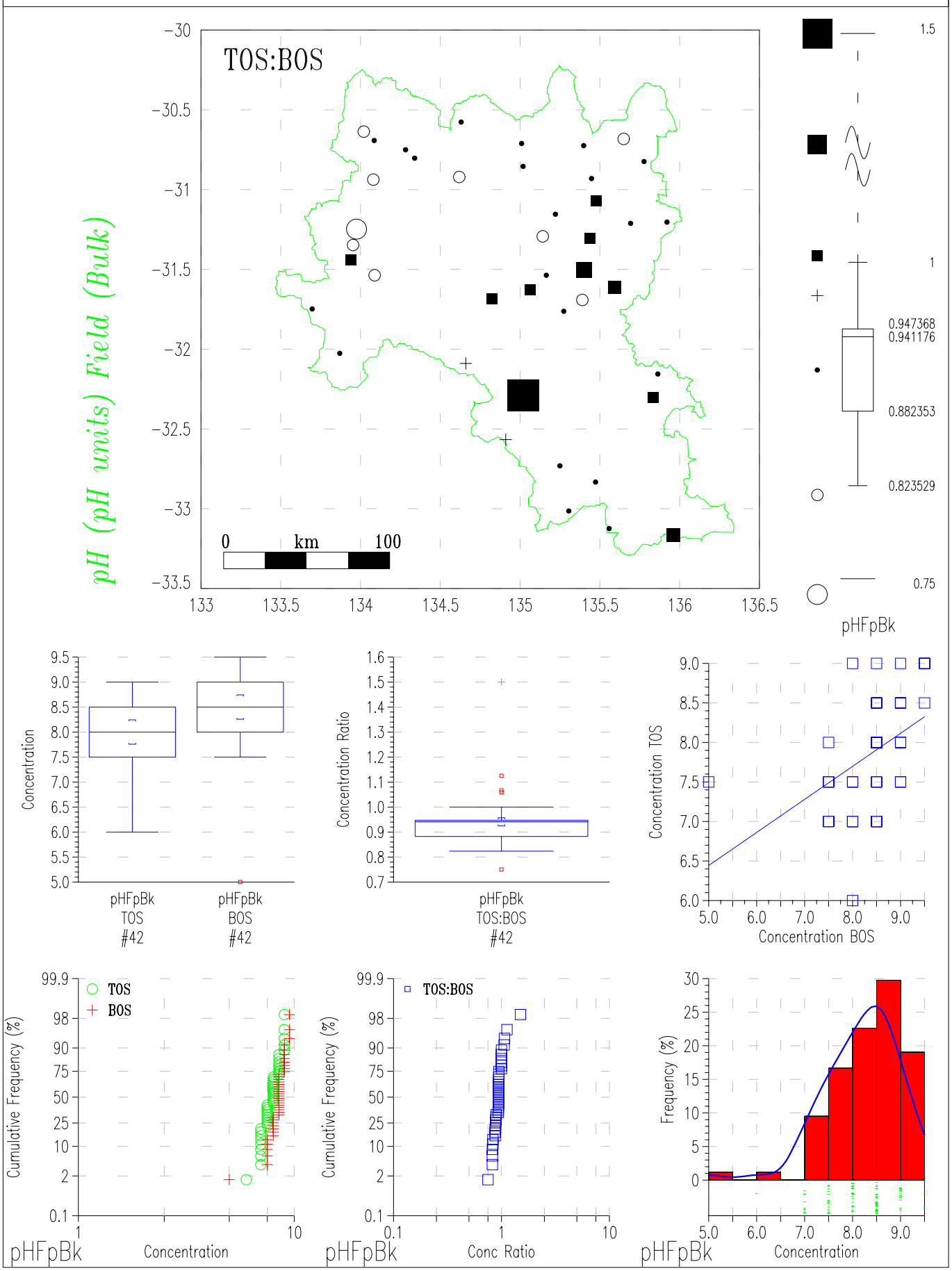
Top & Bottom Outlet Sediments (TOS & BOS)

pH (pH units) Field (Bulk)



GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



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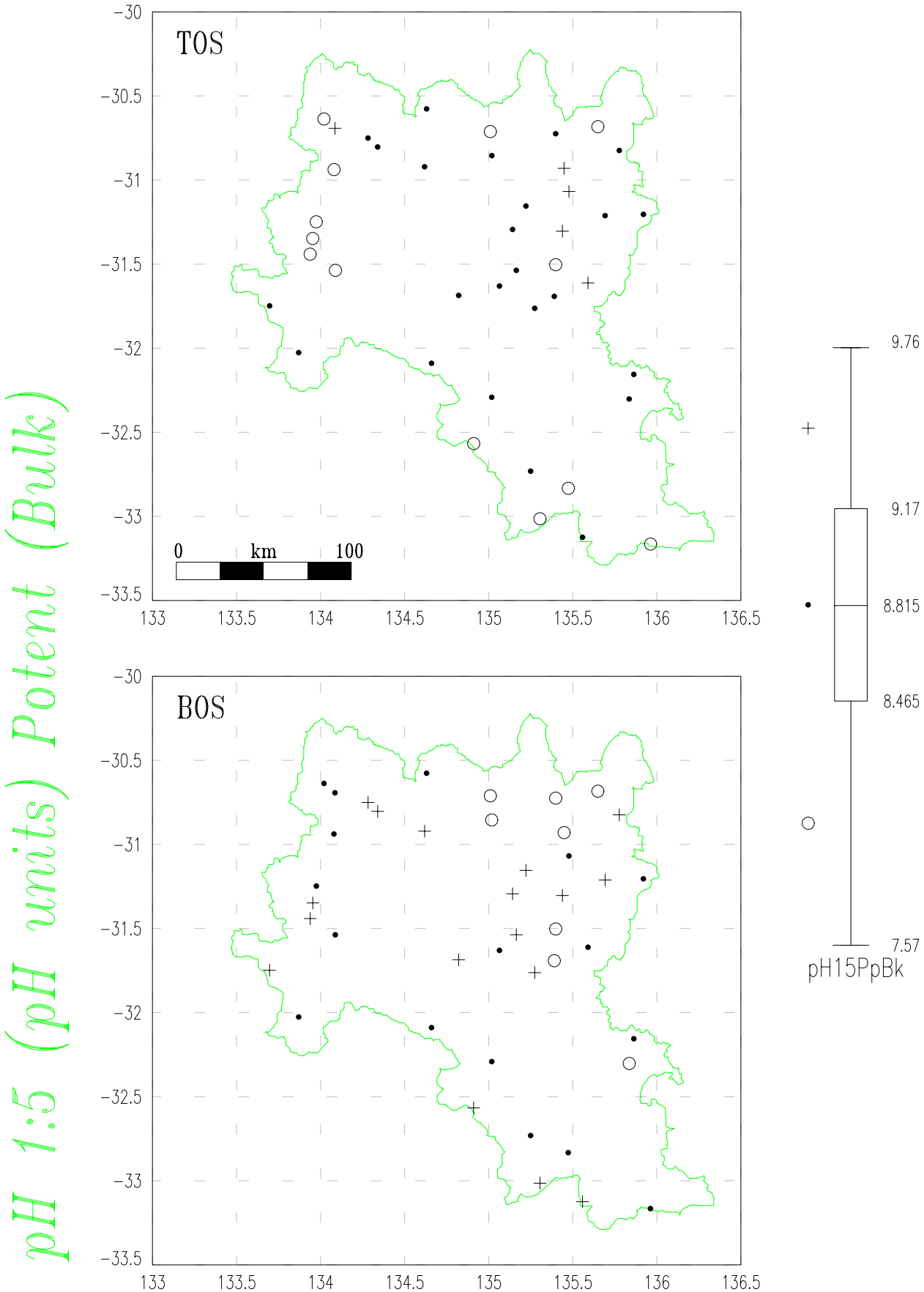
Top & Bottom Outlet Sediments (TOS & BOS)



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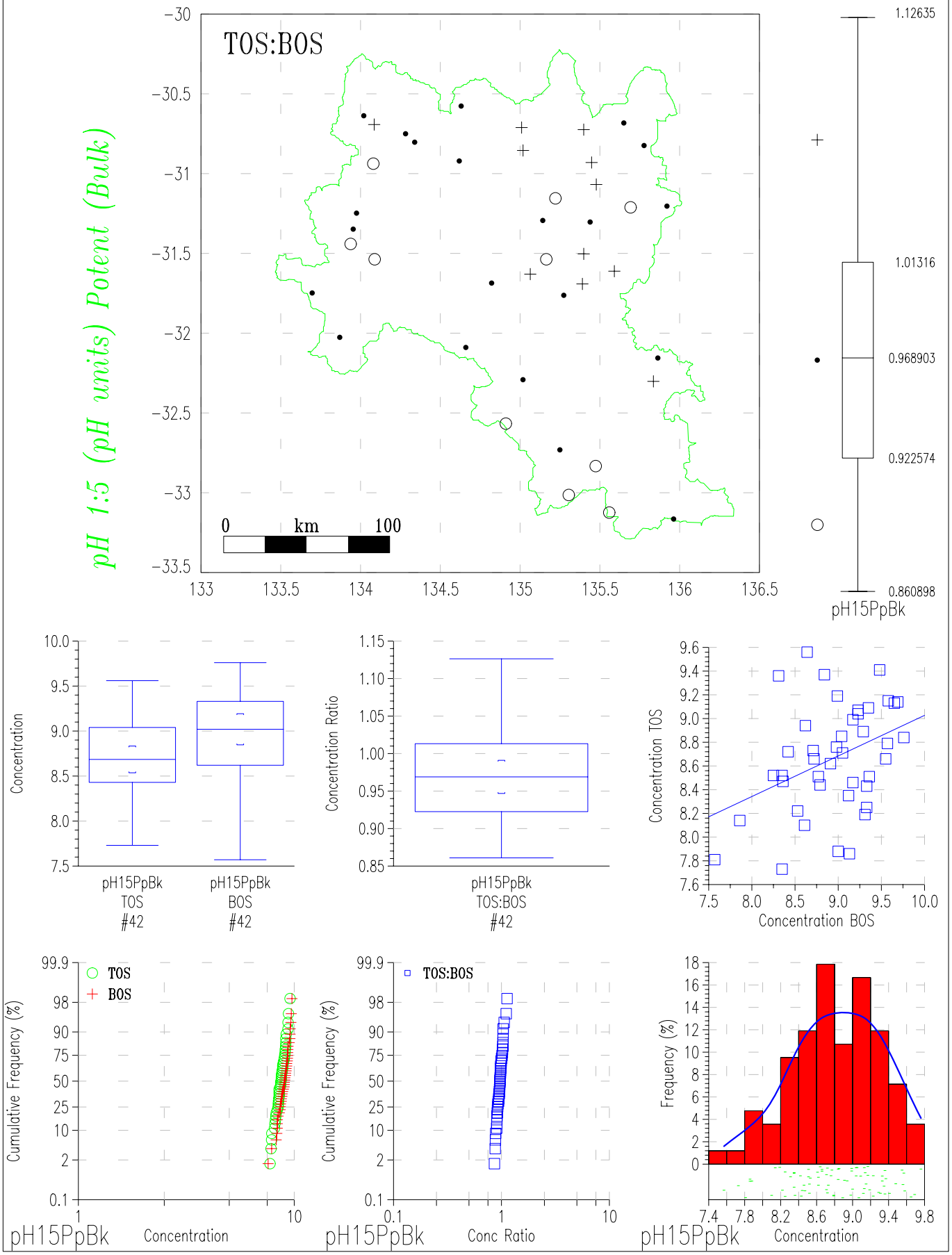
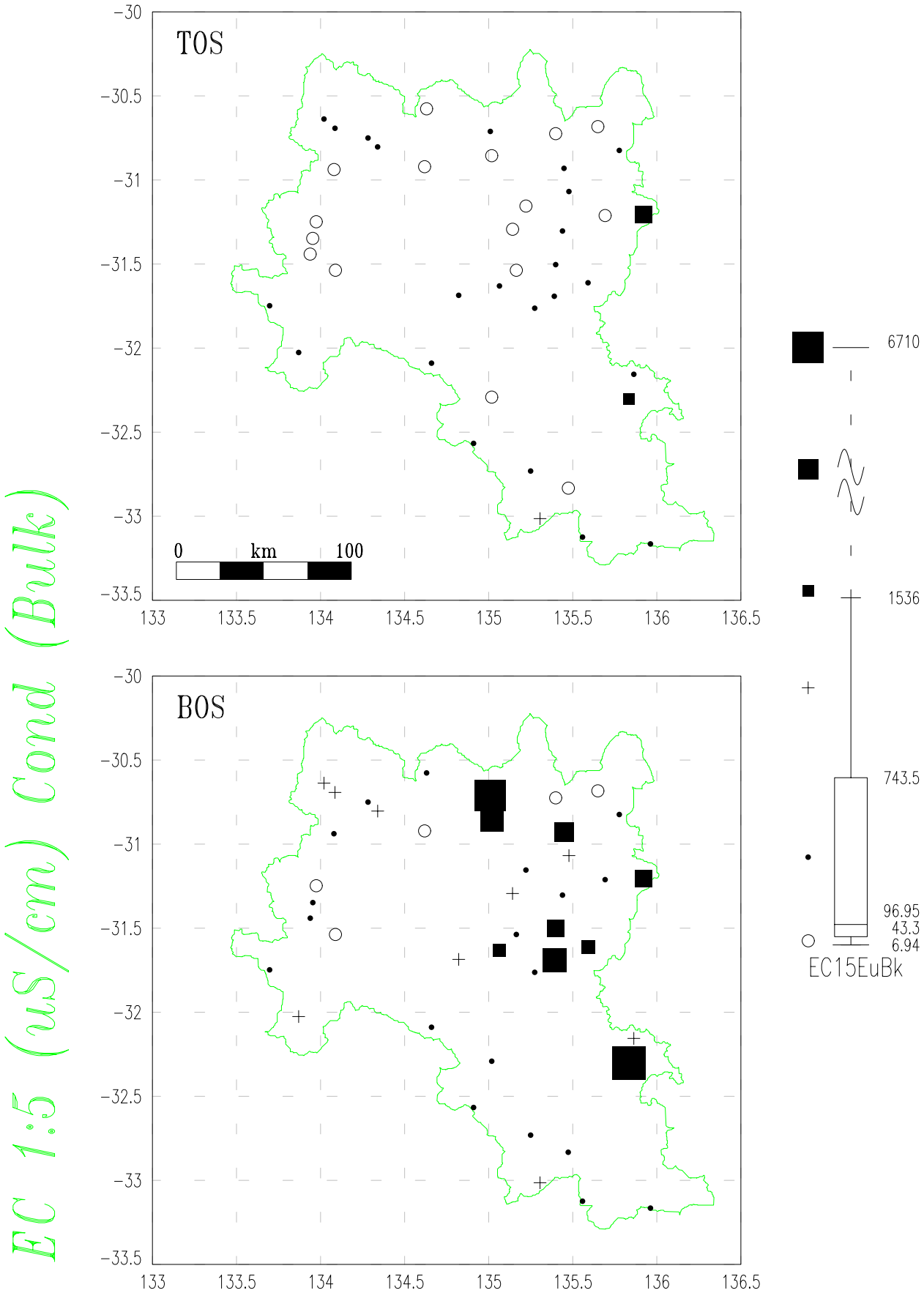
Top & Bottom Outlet Sediments (TOS & BOS)



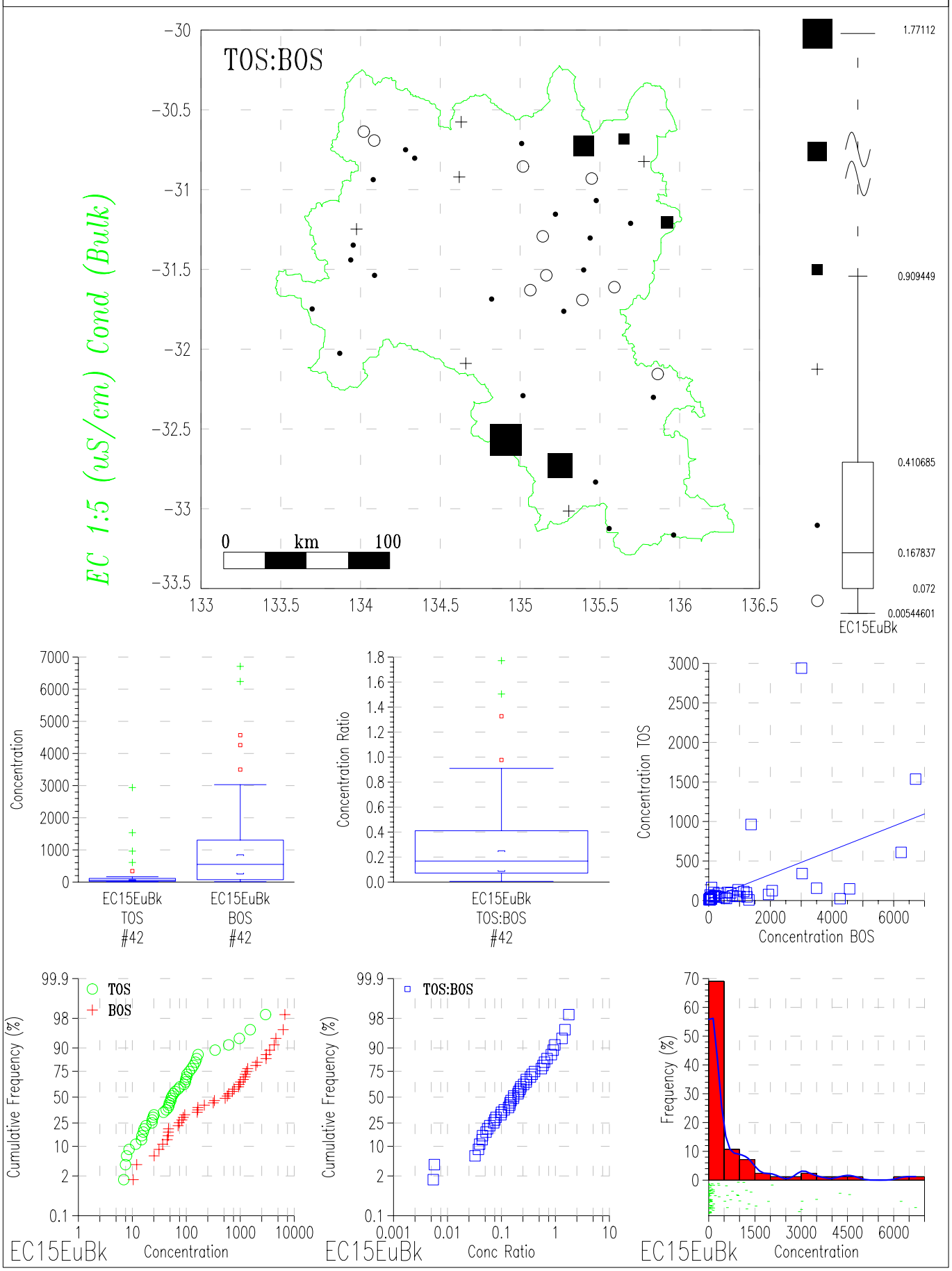
GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



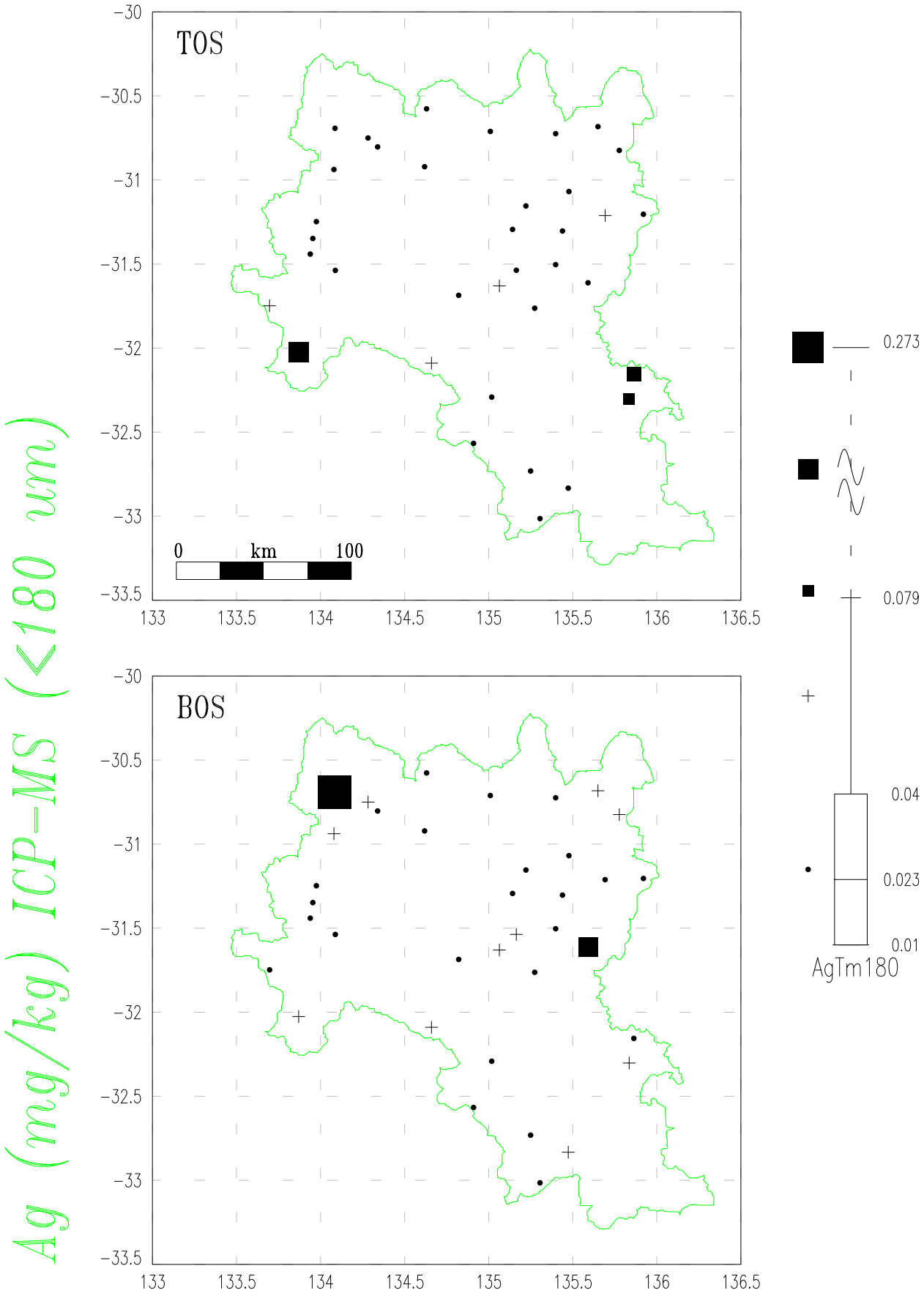
GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



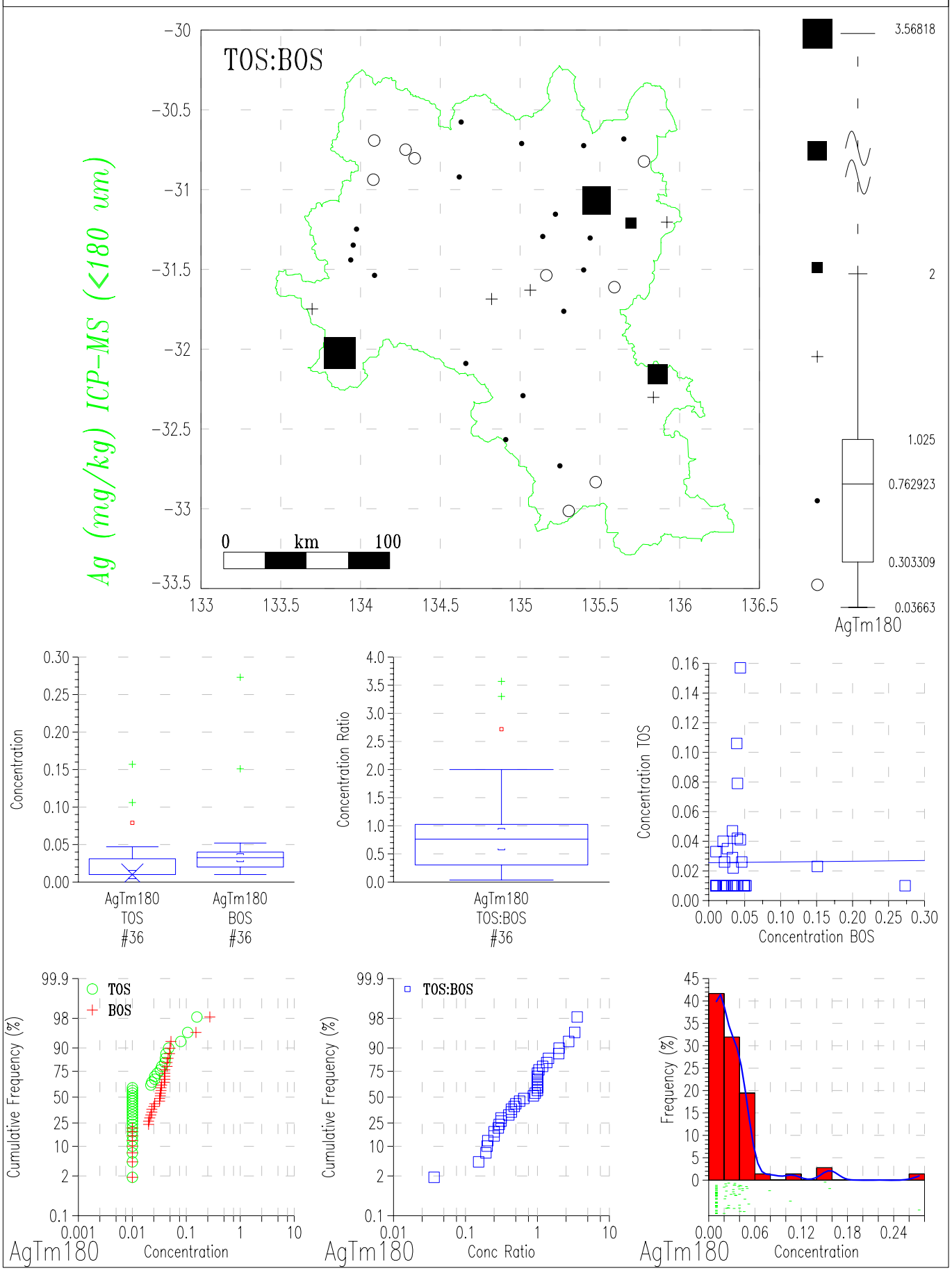
GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



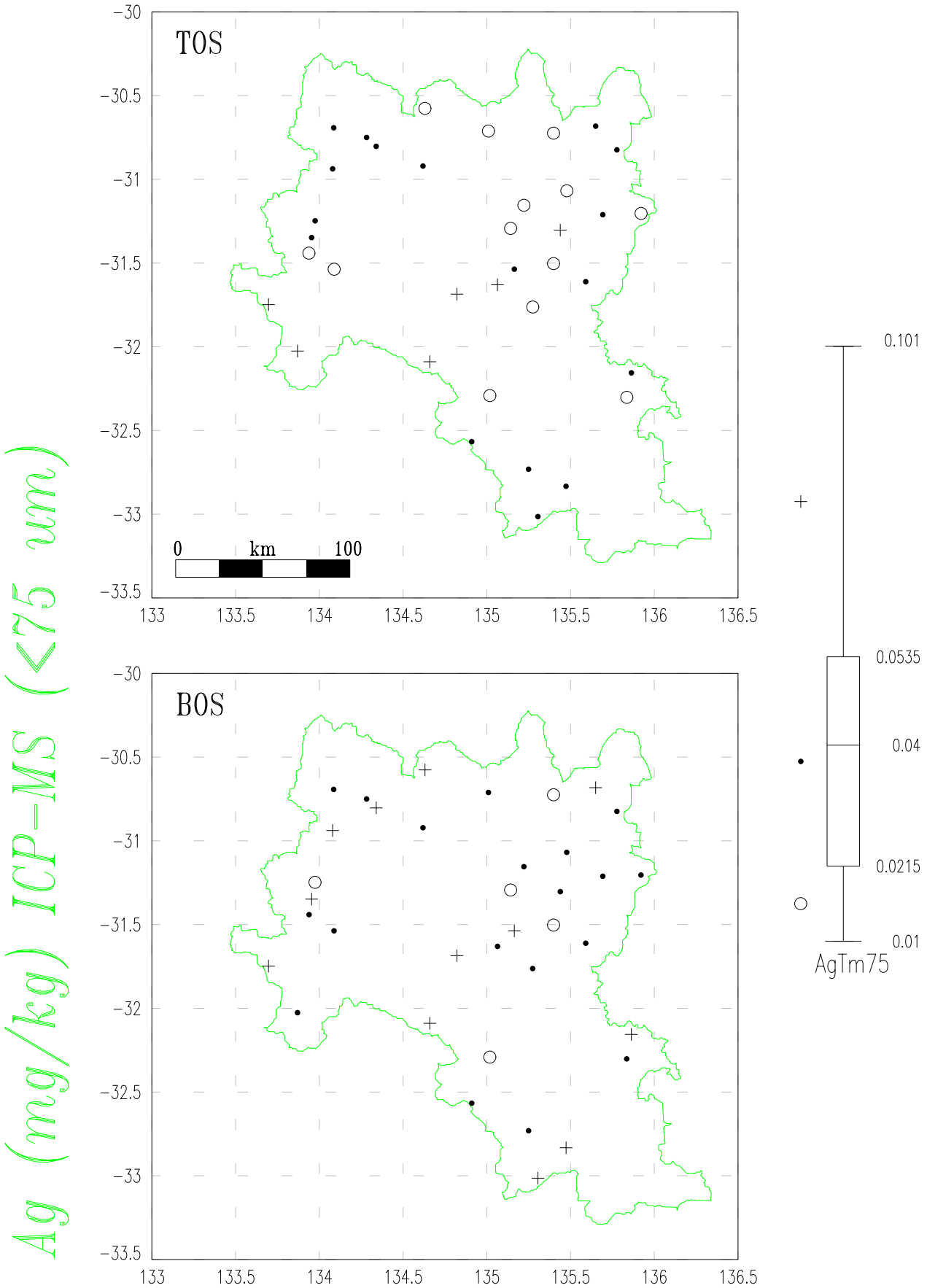
GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



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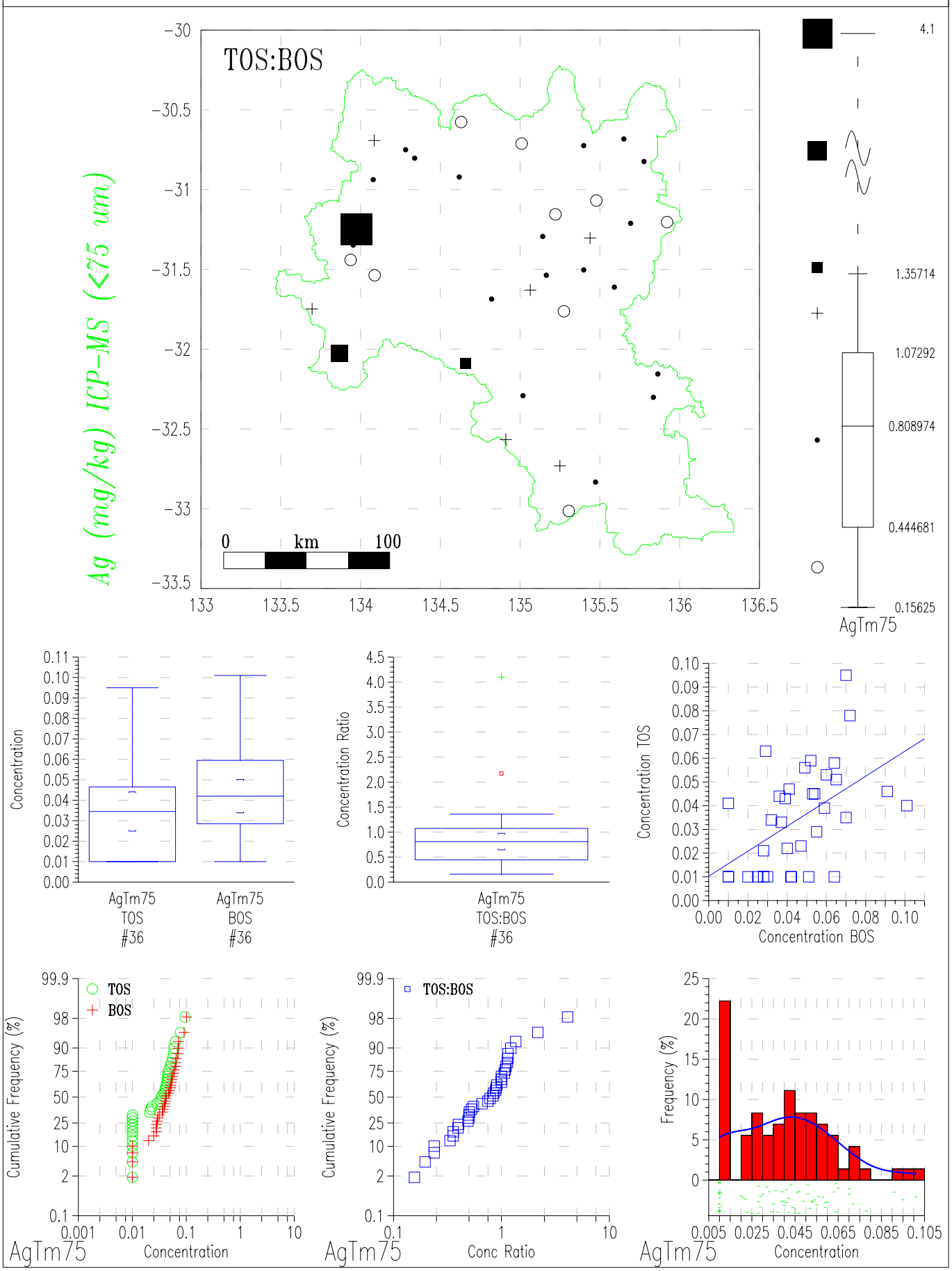
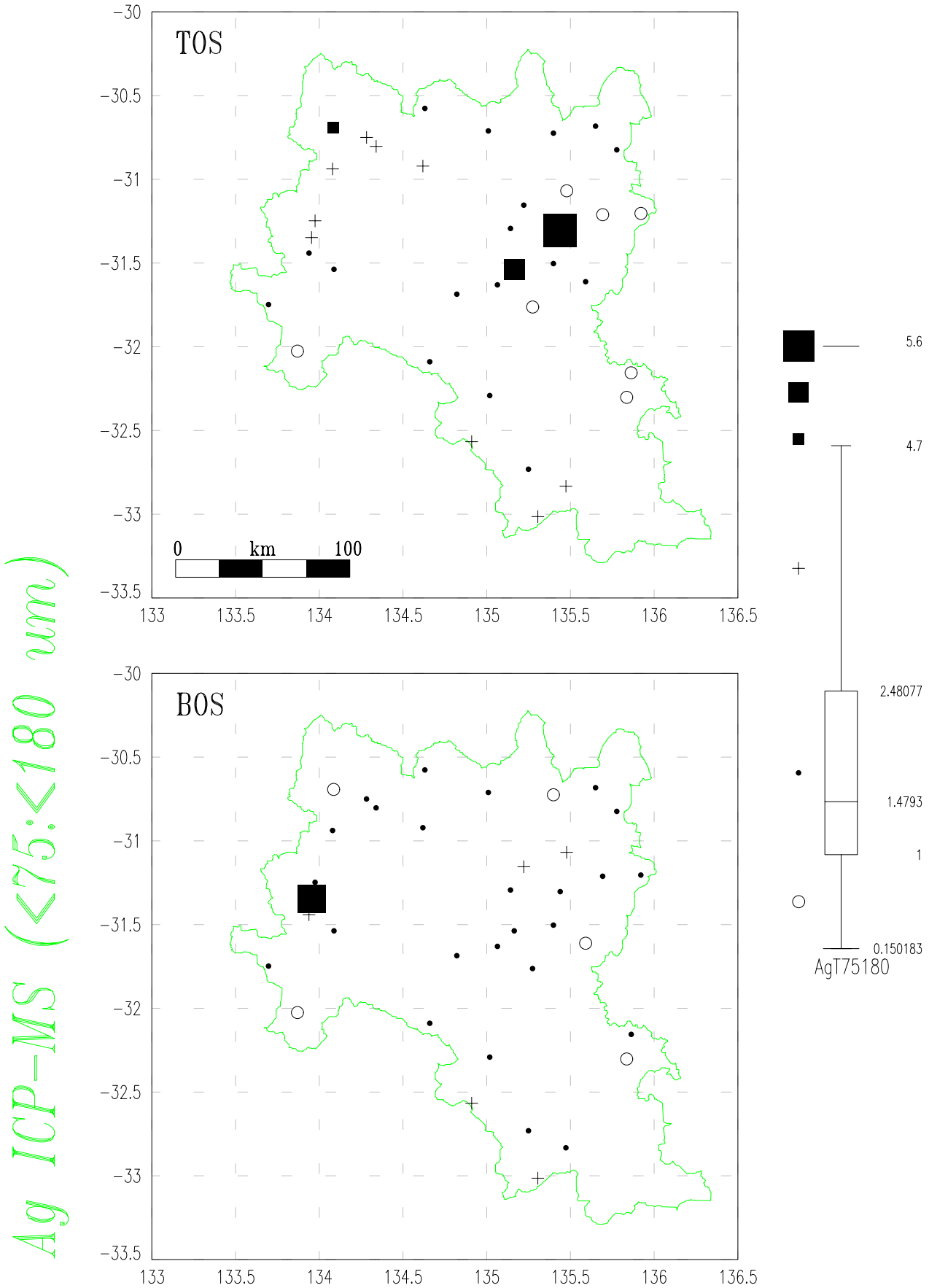
Top & Bottom Outlet Sediments (TOS & BOS)



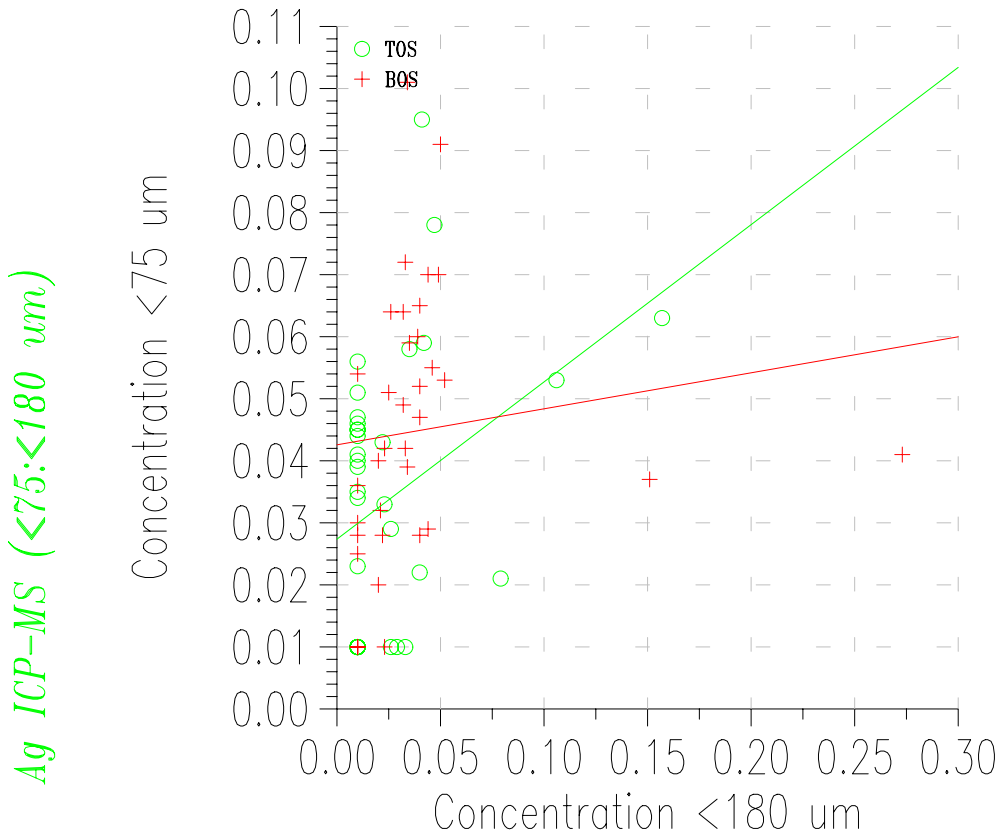
GAWLER GEOCHEMICAL SURVEY

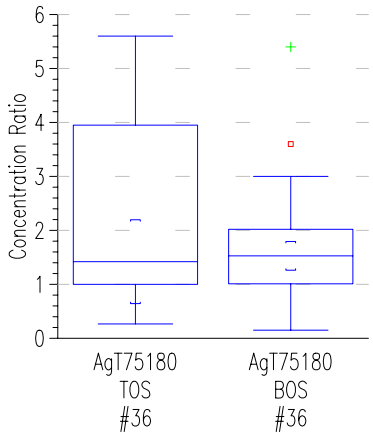
Top & Bottom Outlet Sediments (TOS & BOS)

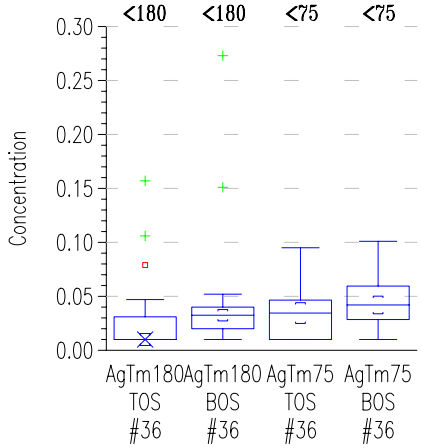


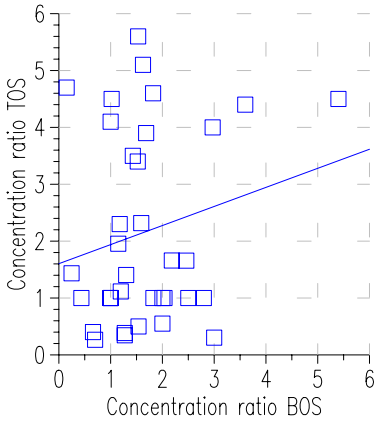
GAWLER GEOCHEMICAL SURVEY

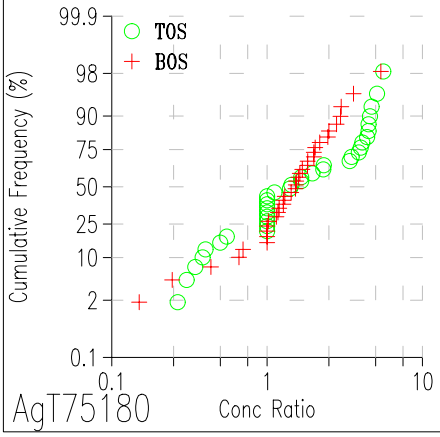
Top & Bottom Outlet Sediments (TOS & BOS)

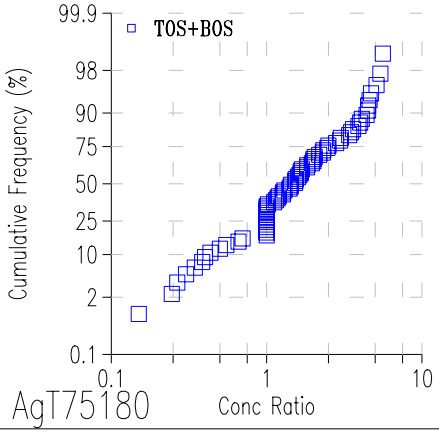


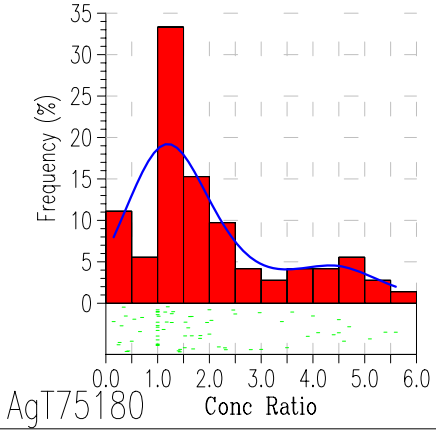






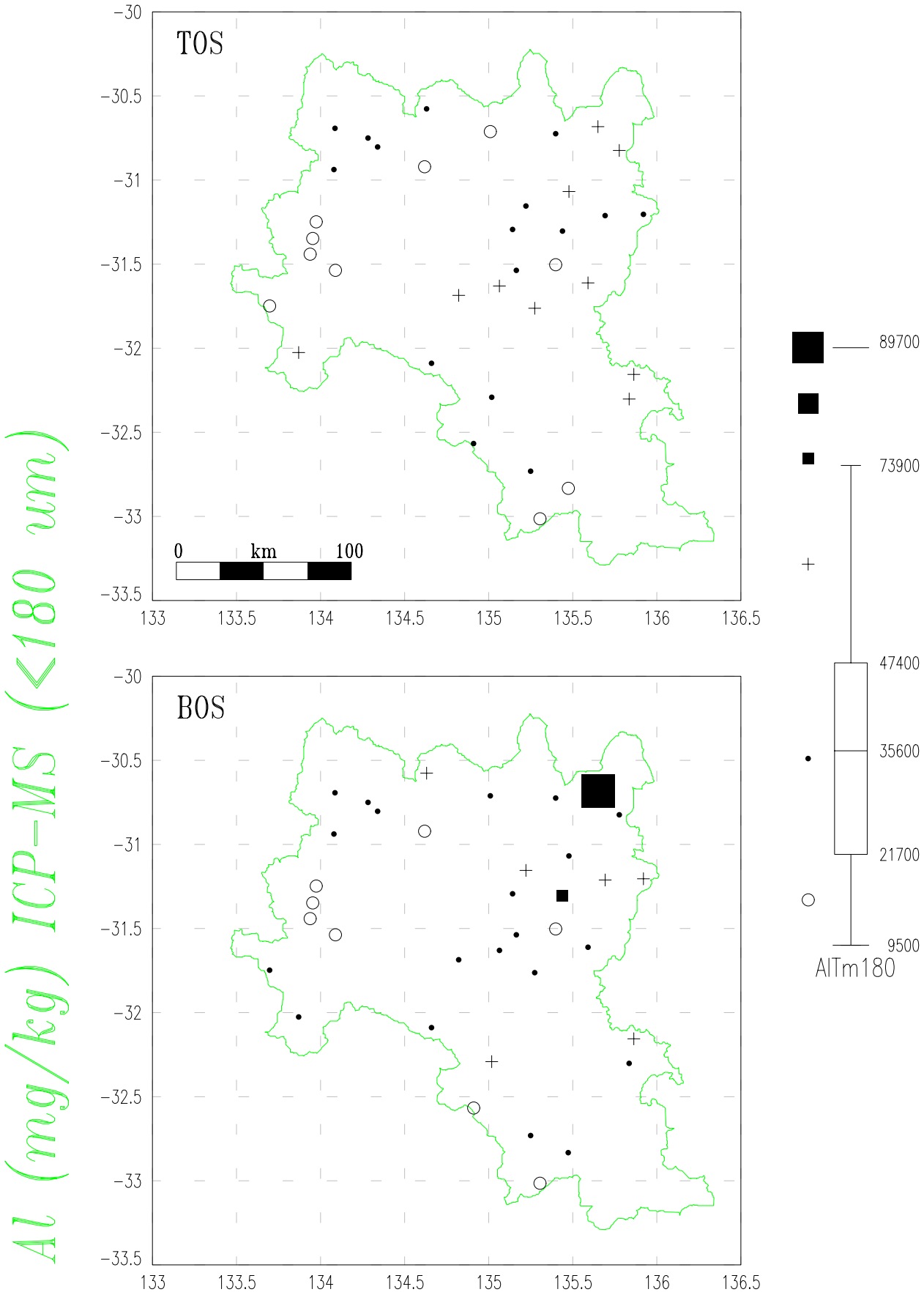






GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



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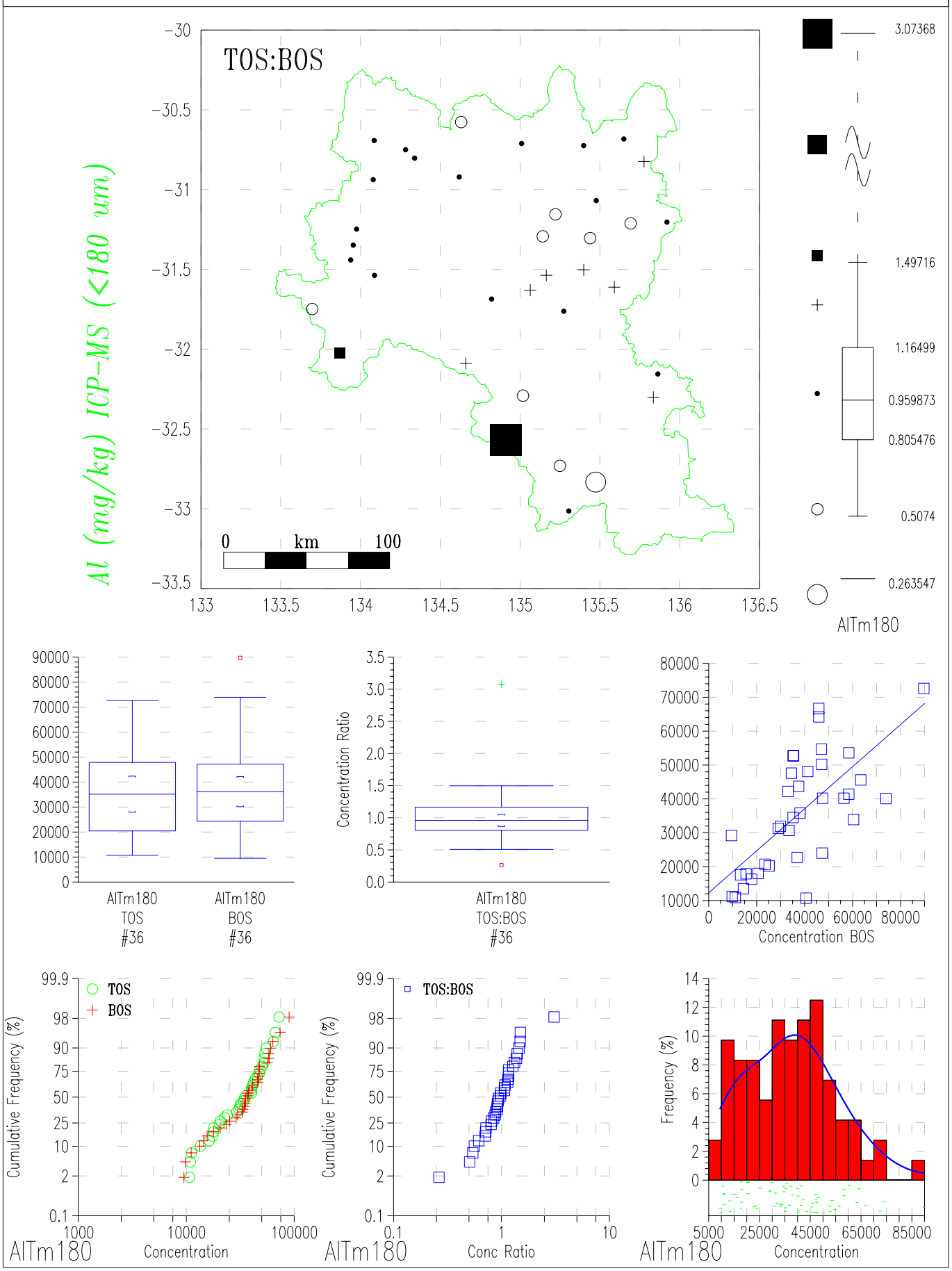
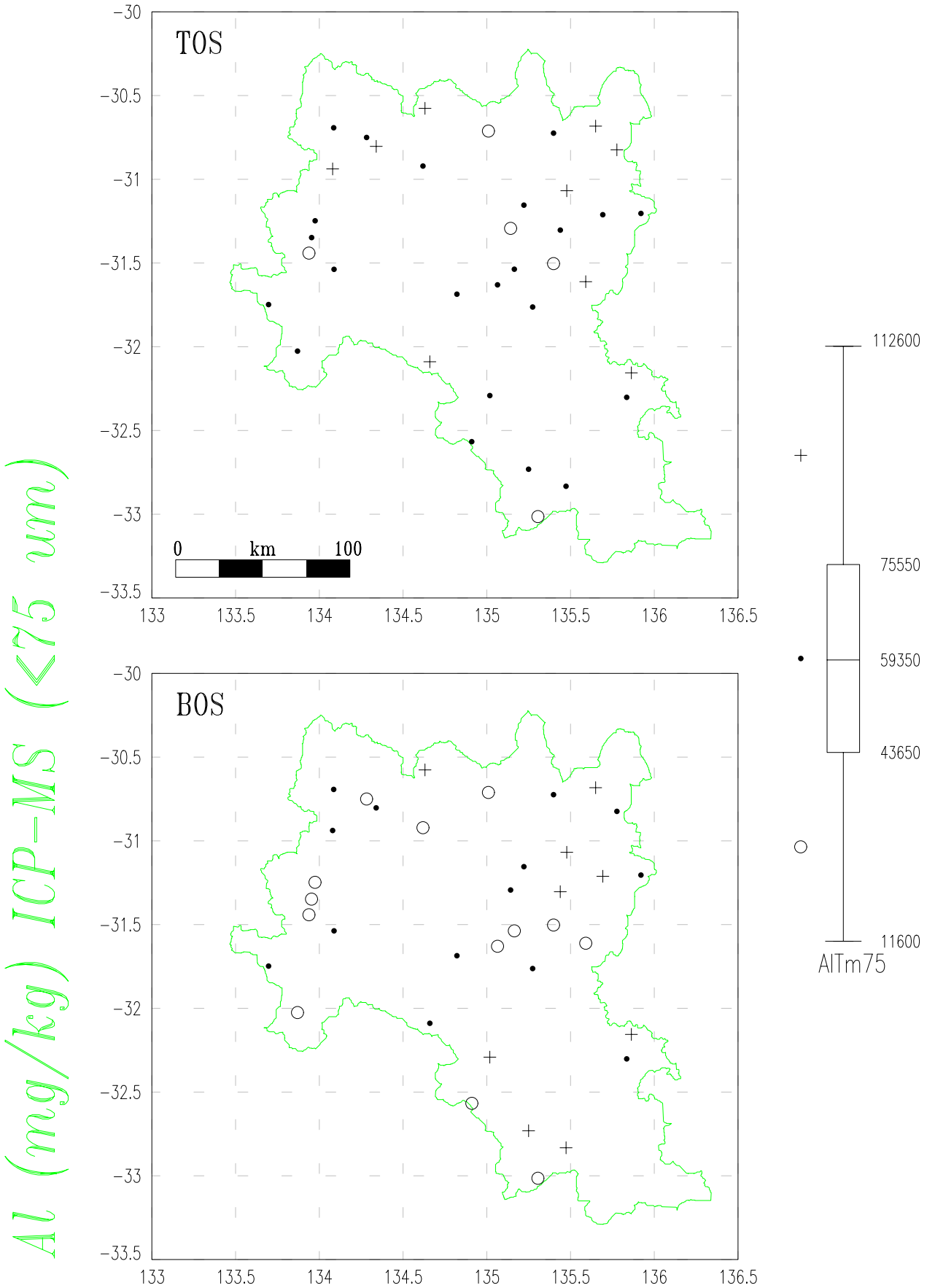
Top & Bottom Outlet Sediments (TOS & BOS)



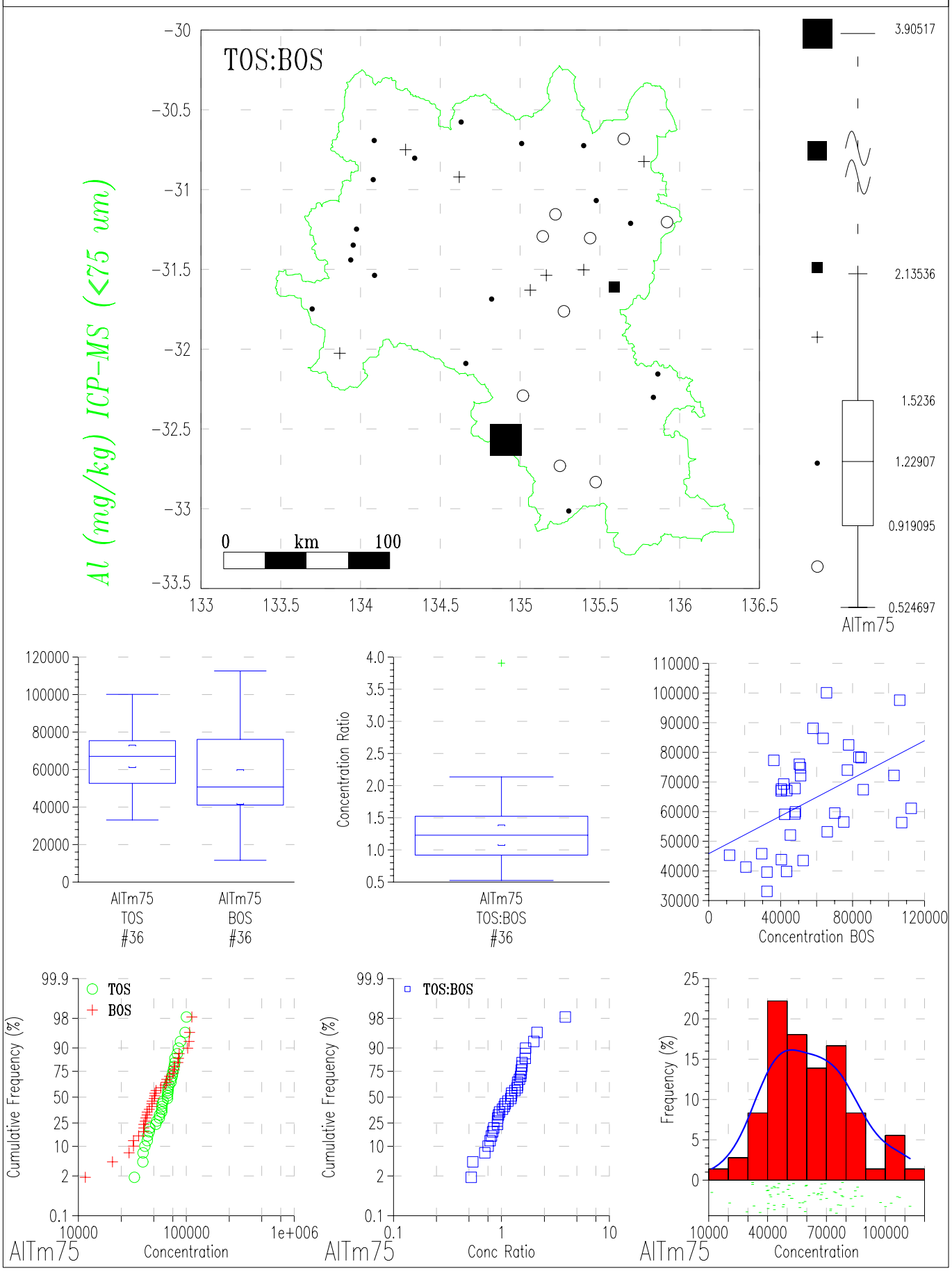
GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



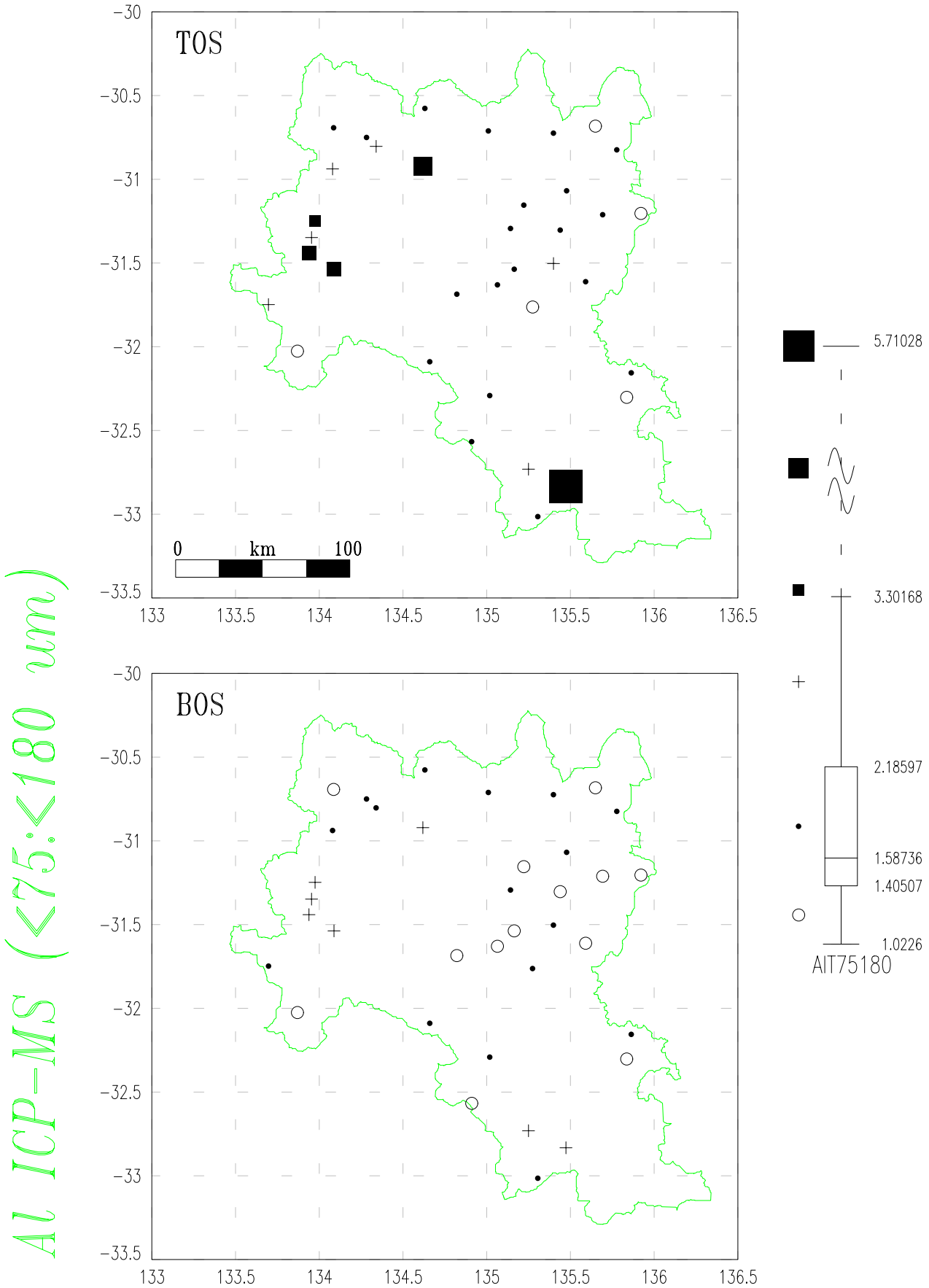
GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



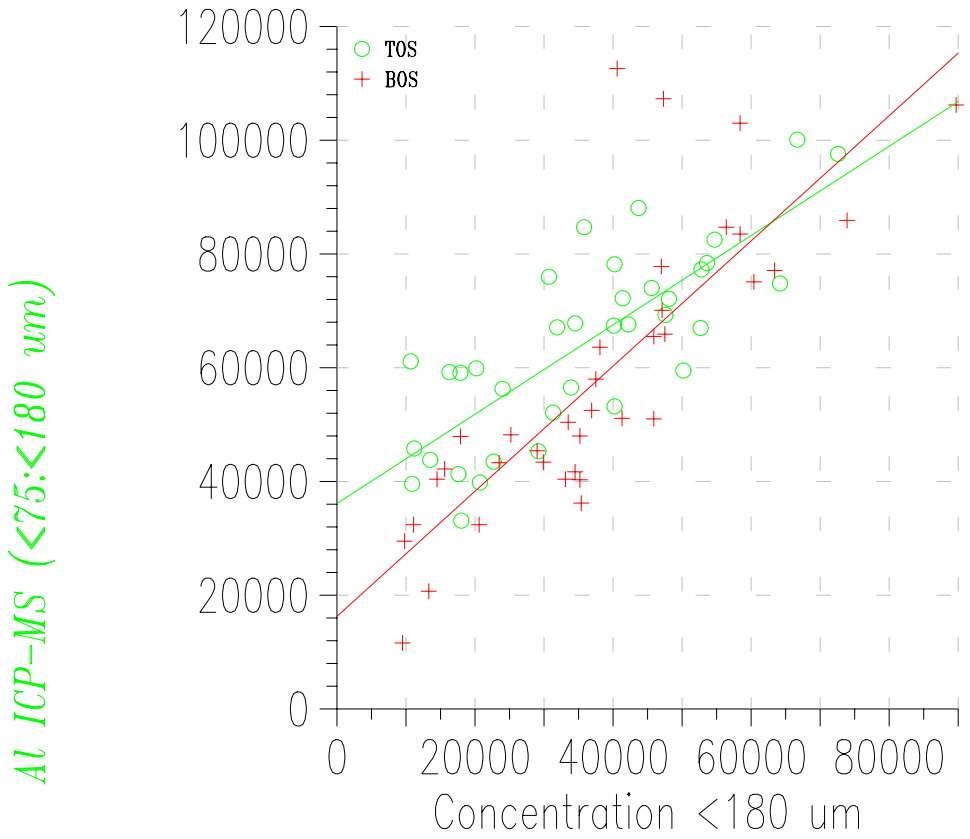
GAWLER GEOCHEMICAL SURVEY

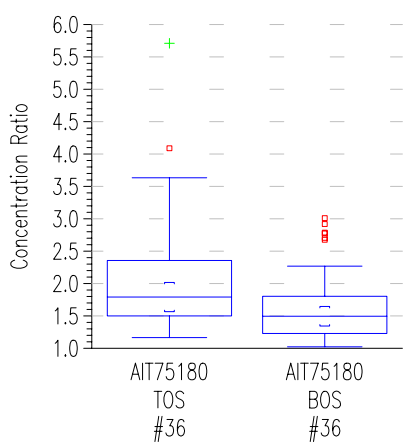
Top & Bottom Outlet Sediments (TOS & BOS)

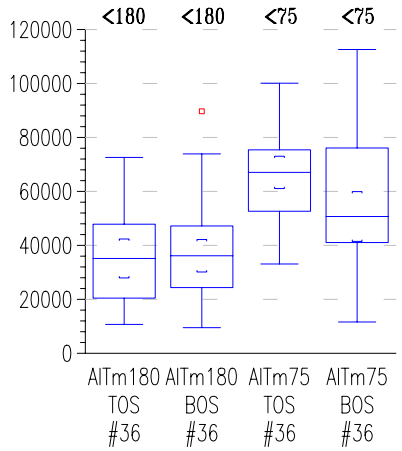


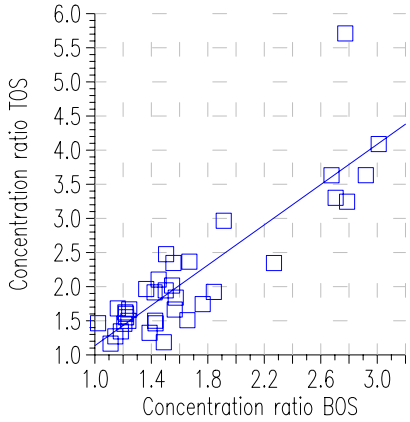
GAWLER GEOCHEMICAL SURVEY

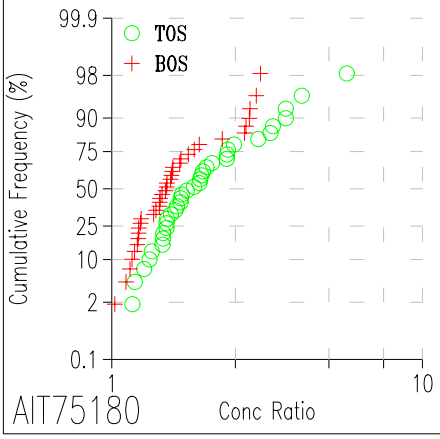
Top & Bottom Outlet Sediments (TOS & BOS)

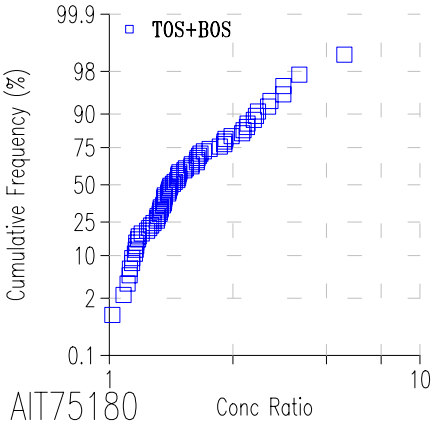


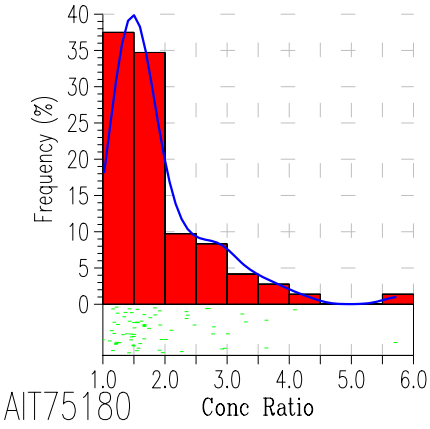






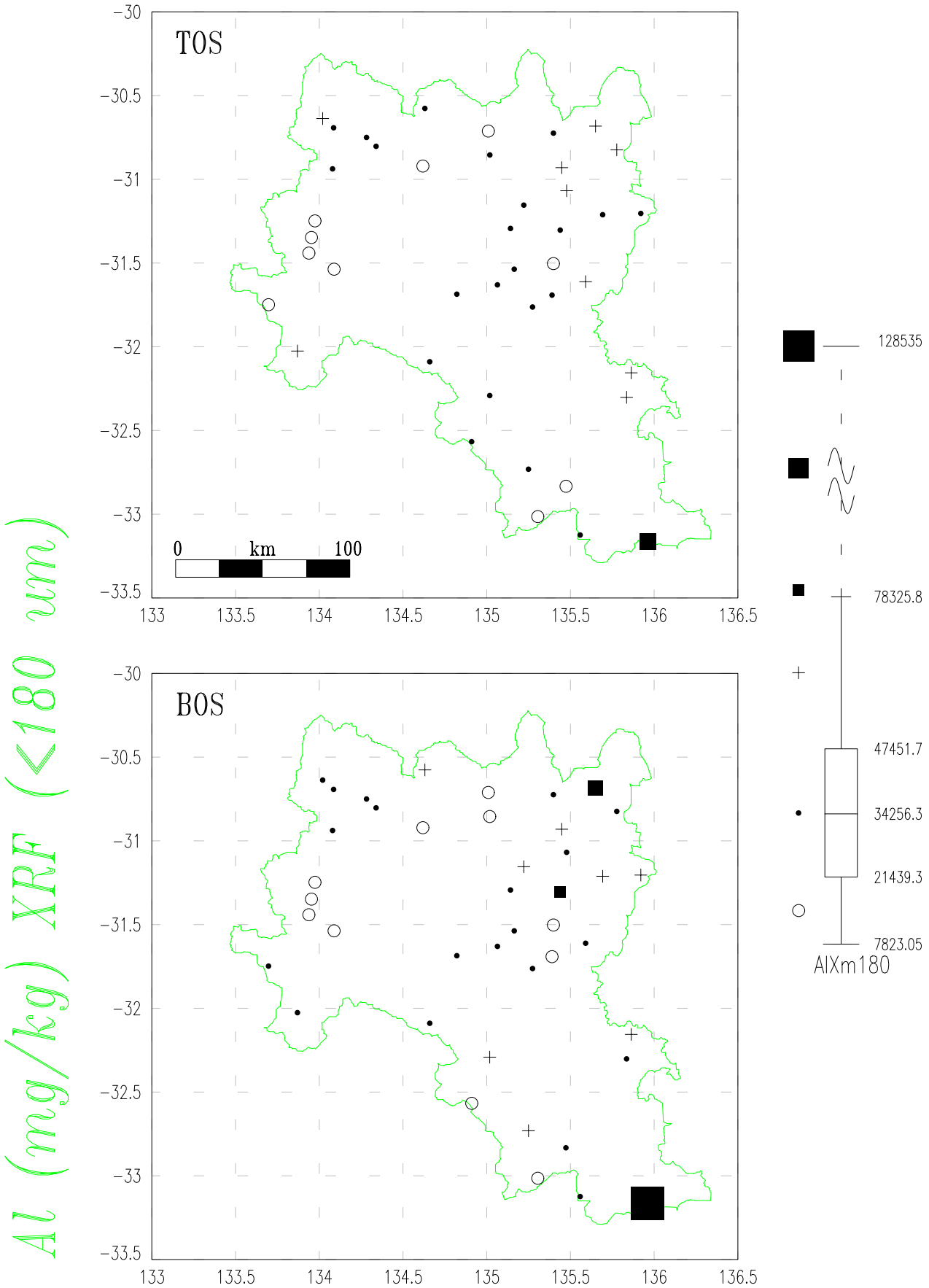






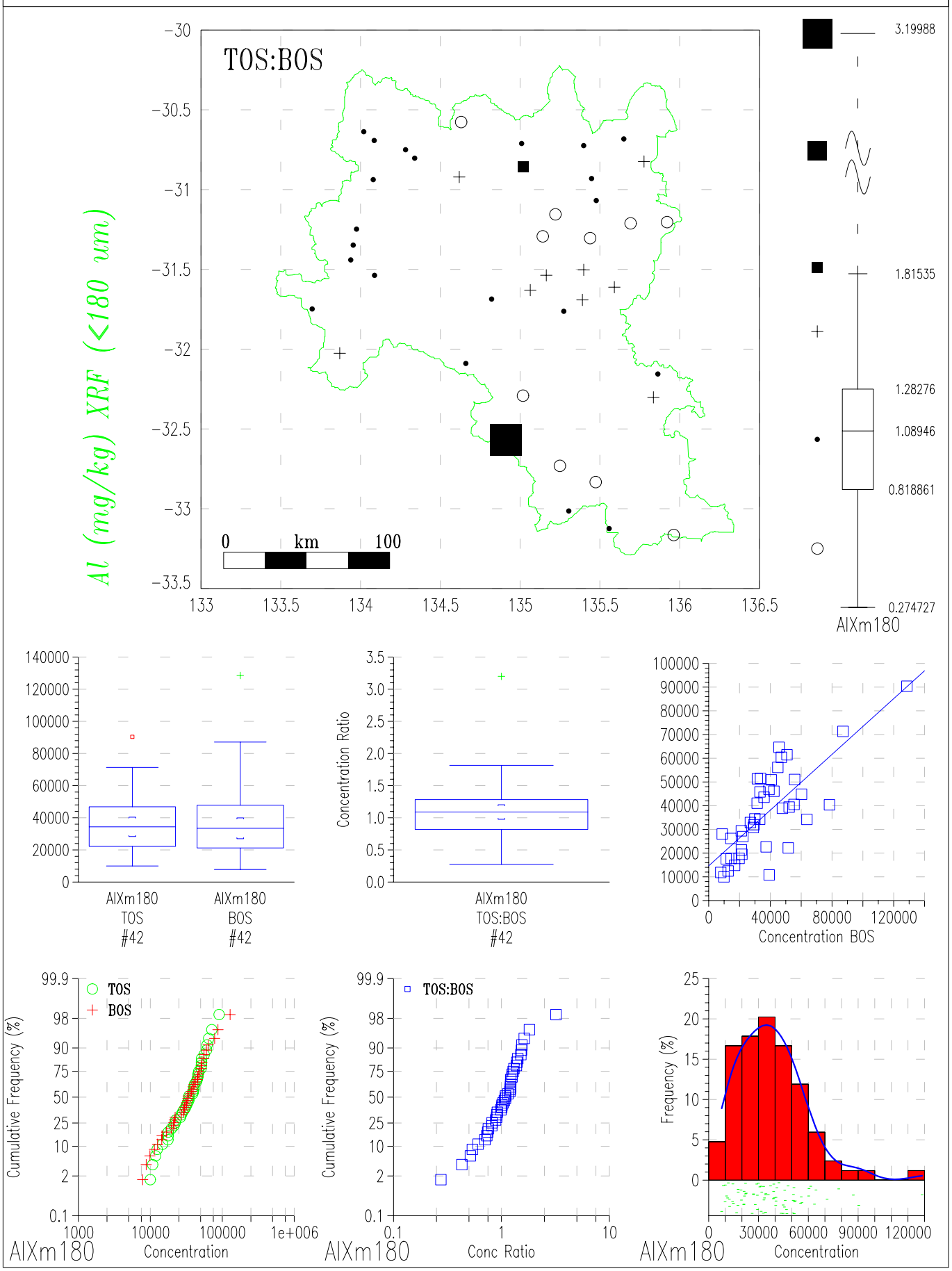
GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



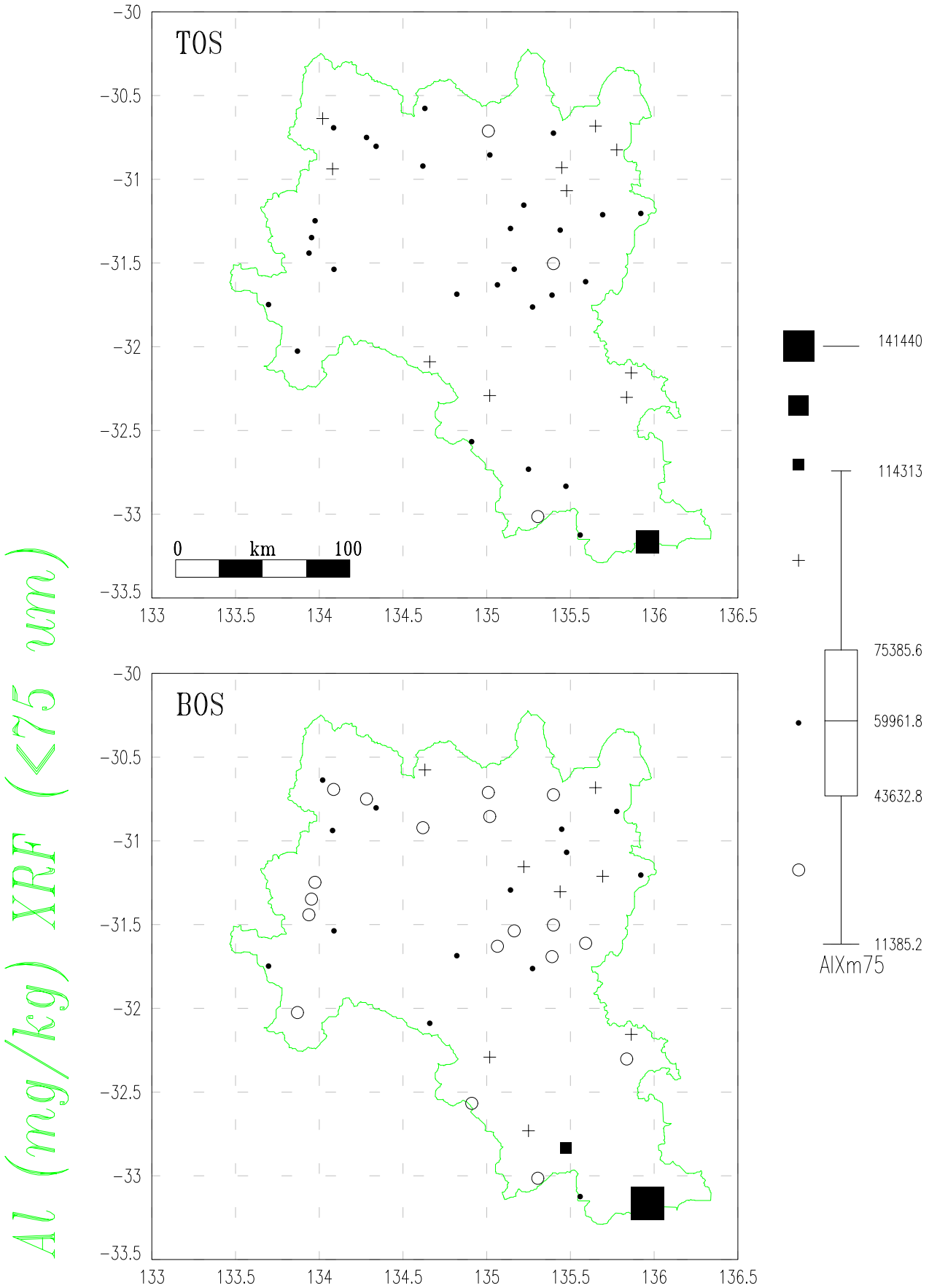
GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



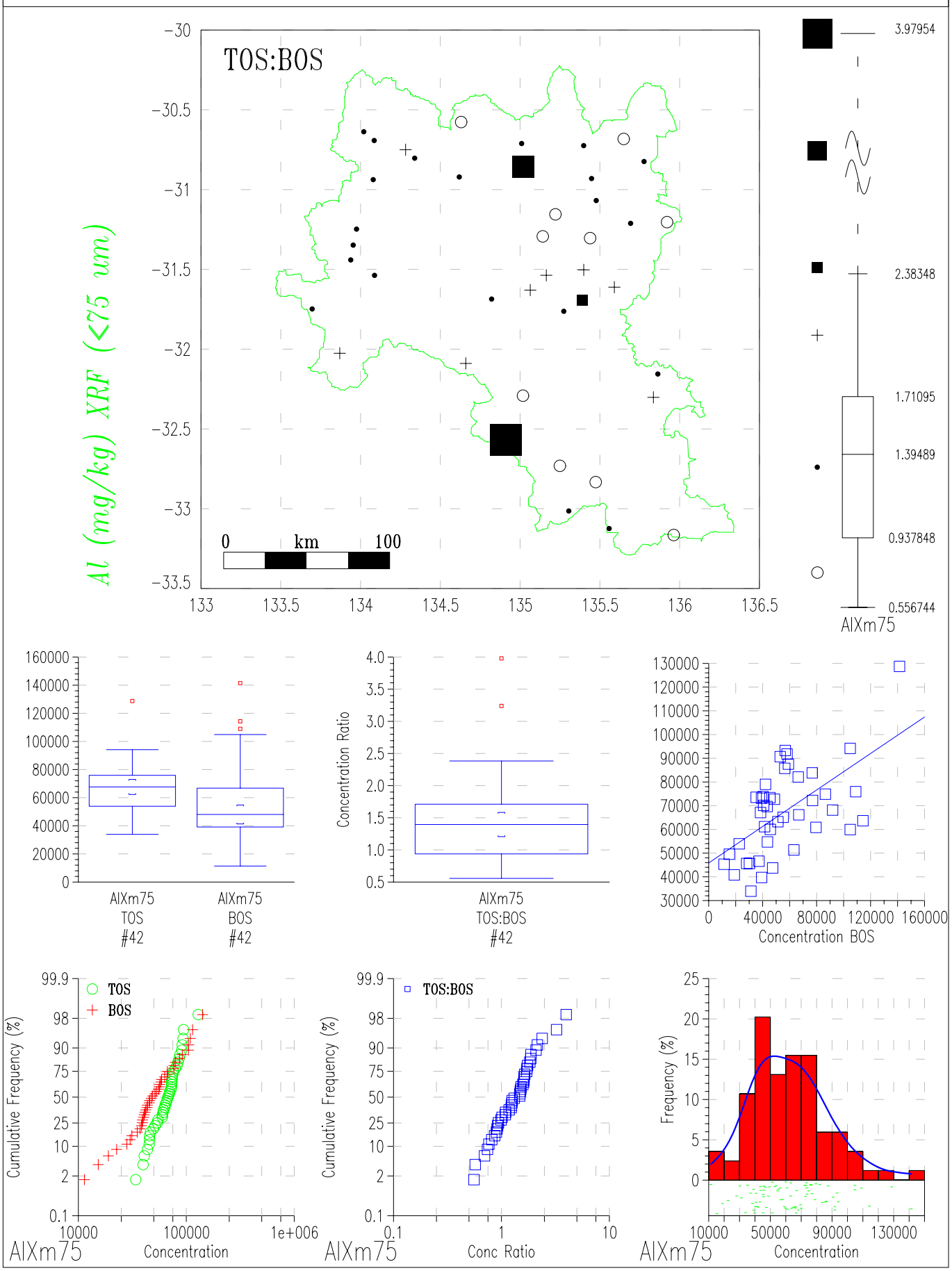
GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



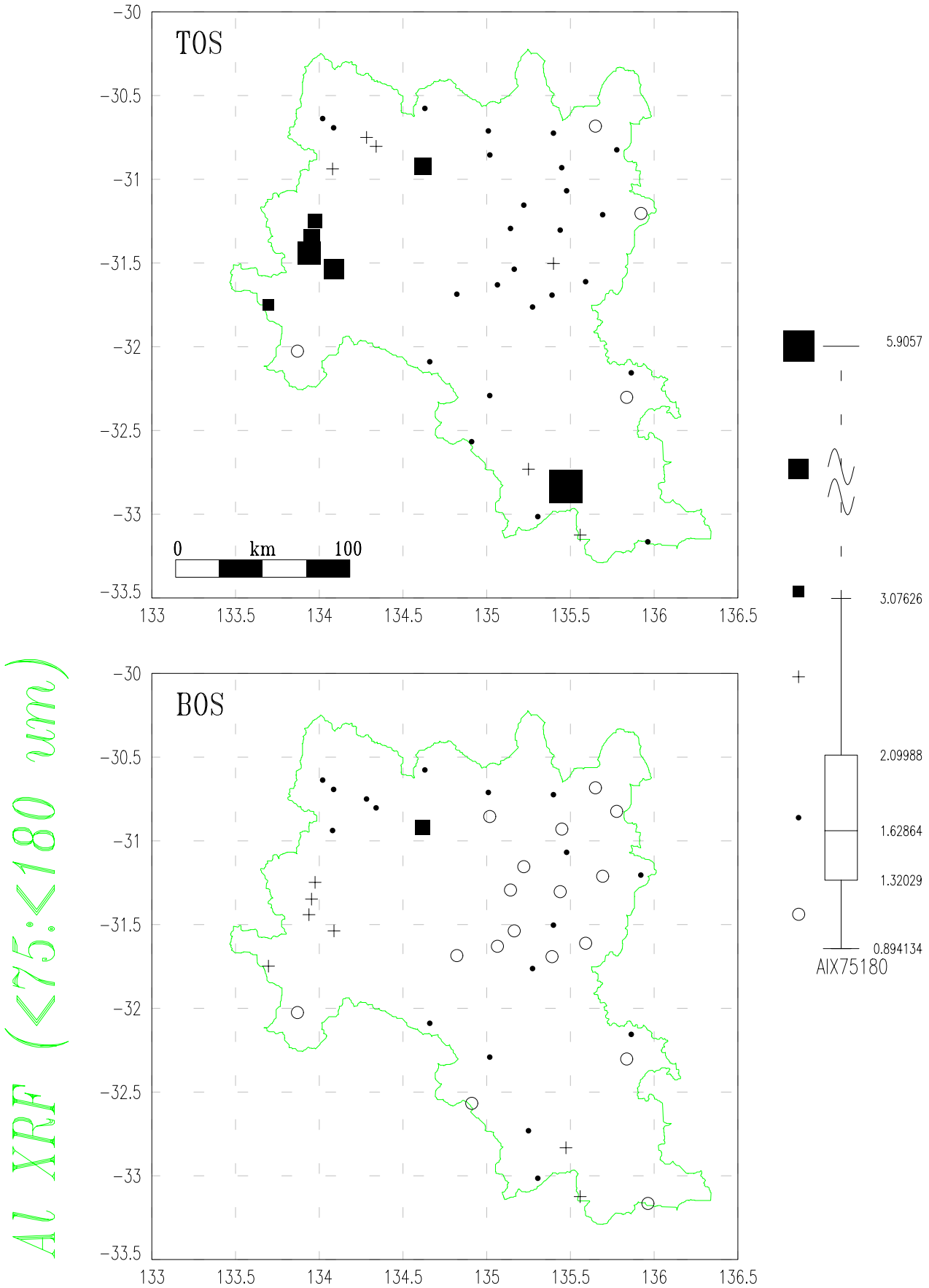
GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



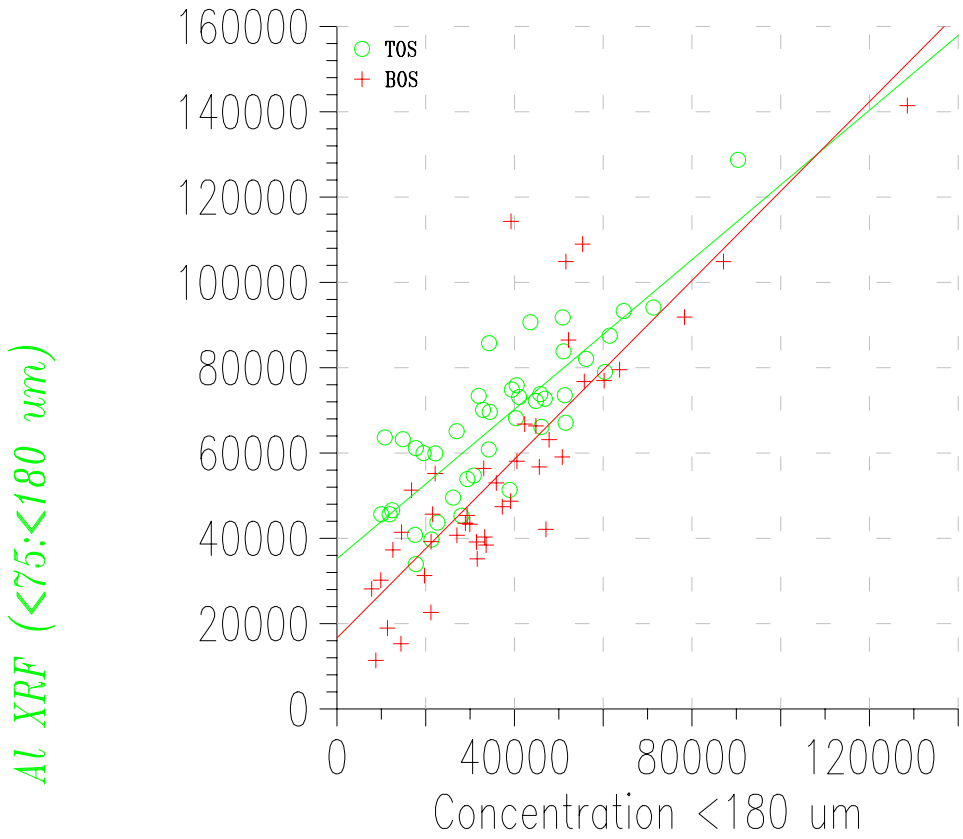
GAWLER GEOCHEMICAL SURVEY

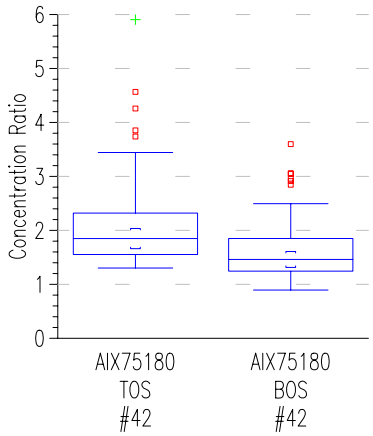
Top & Bottom Outlet Sediments (TOS & BOS)

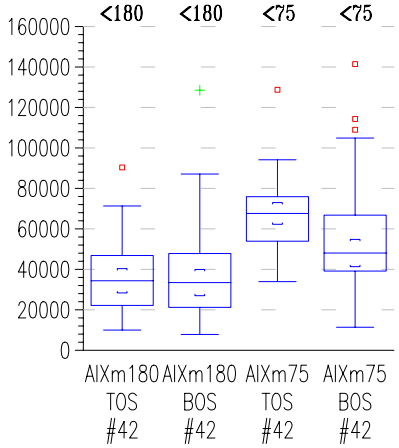


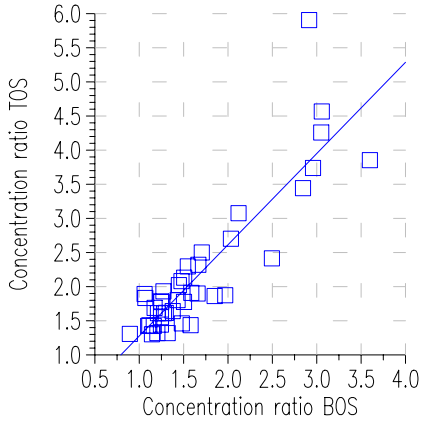
GAWLER GEOCHEMICAL SURVEY

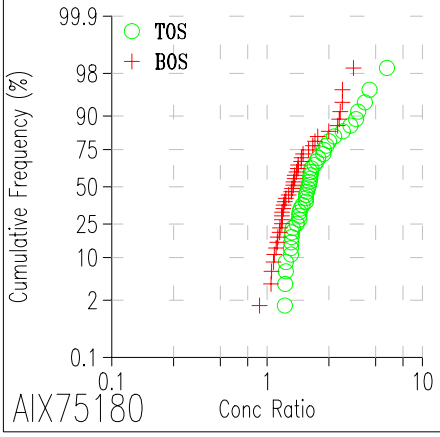
Top & Bottom Outlet Sediments (TOS & BOS)

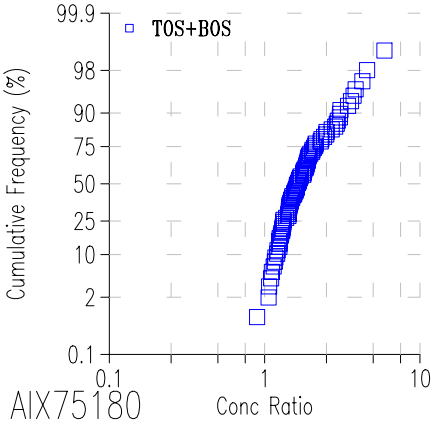


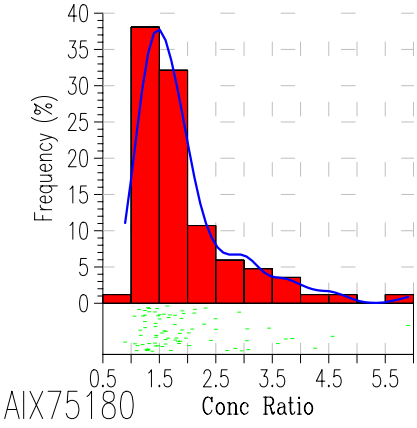






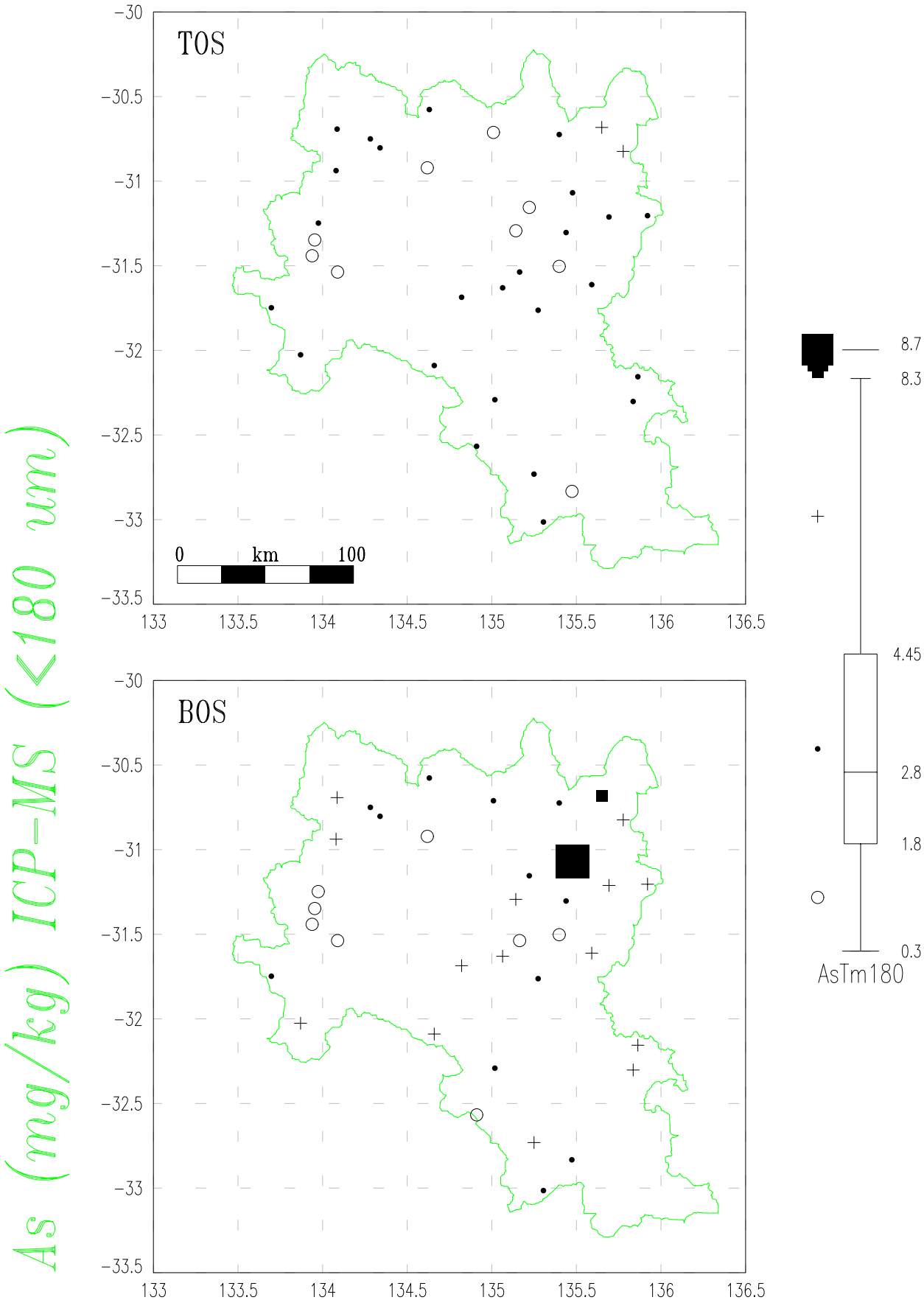






GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



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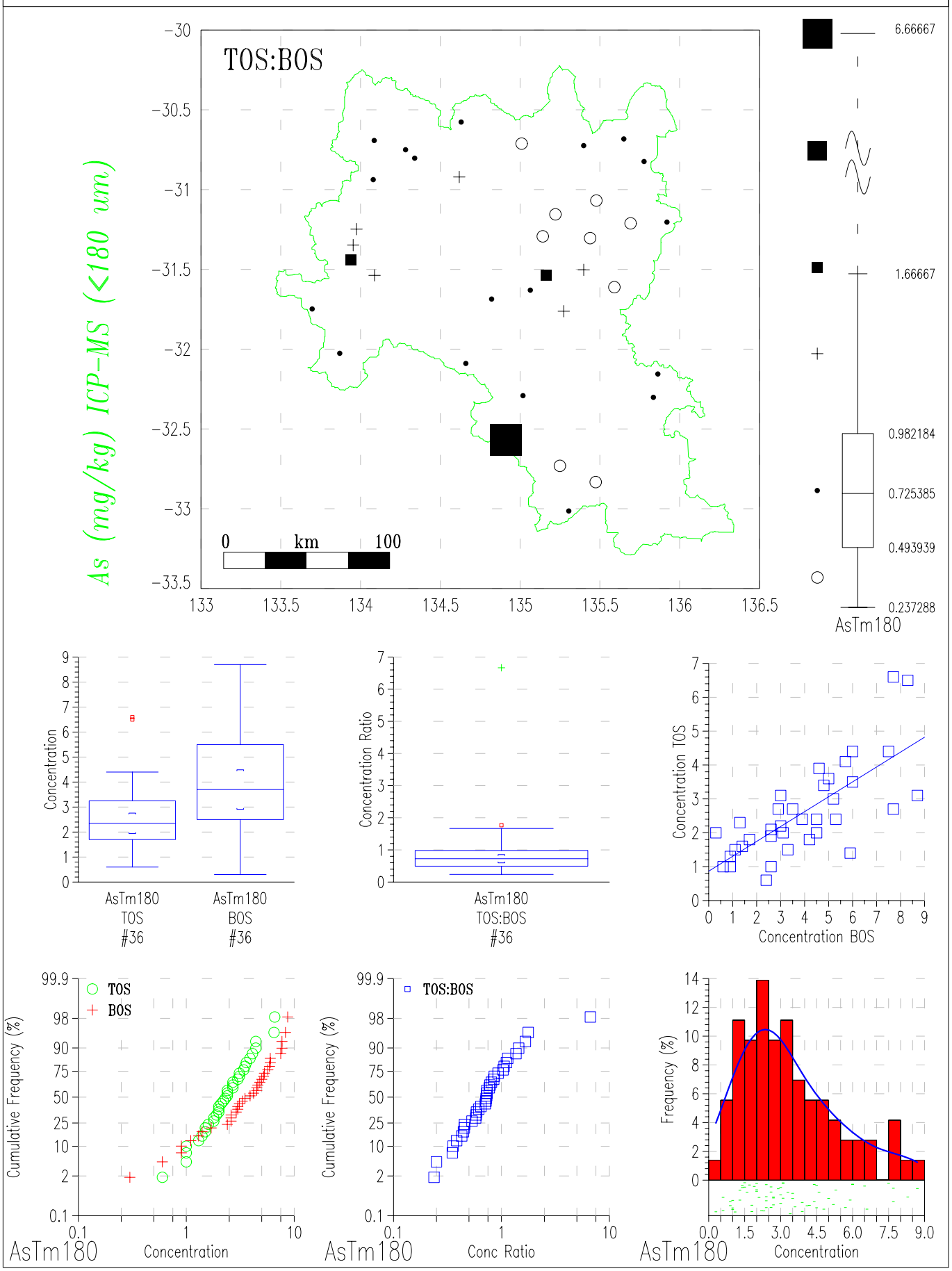
Top & Bottom Outlet Sediments (TOS & BOS)



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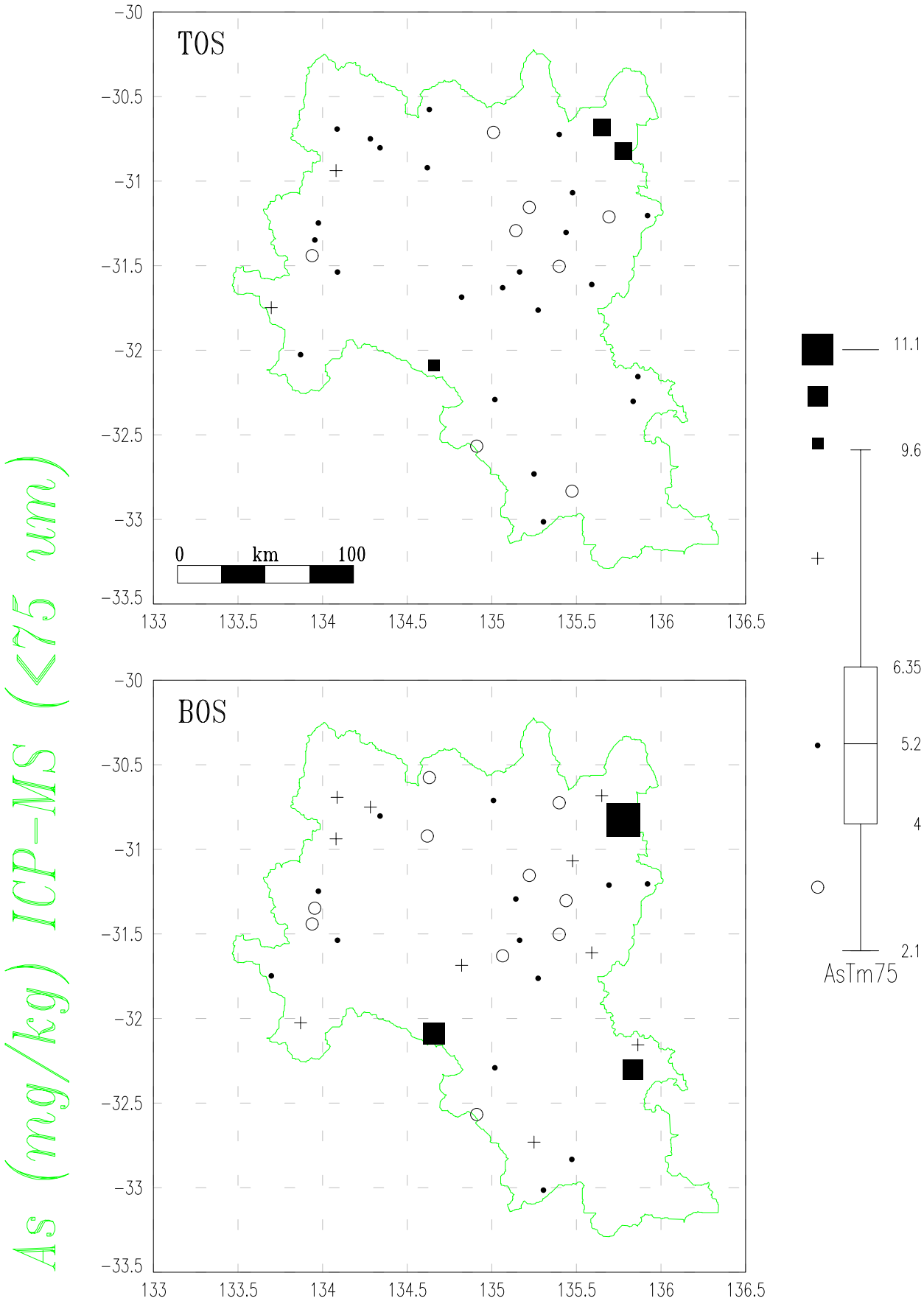
Top & Bottom Outlet Sediments (TOS & BOS)



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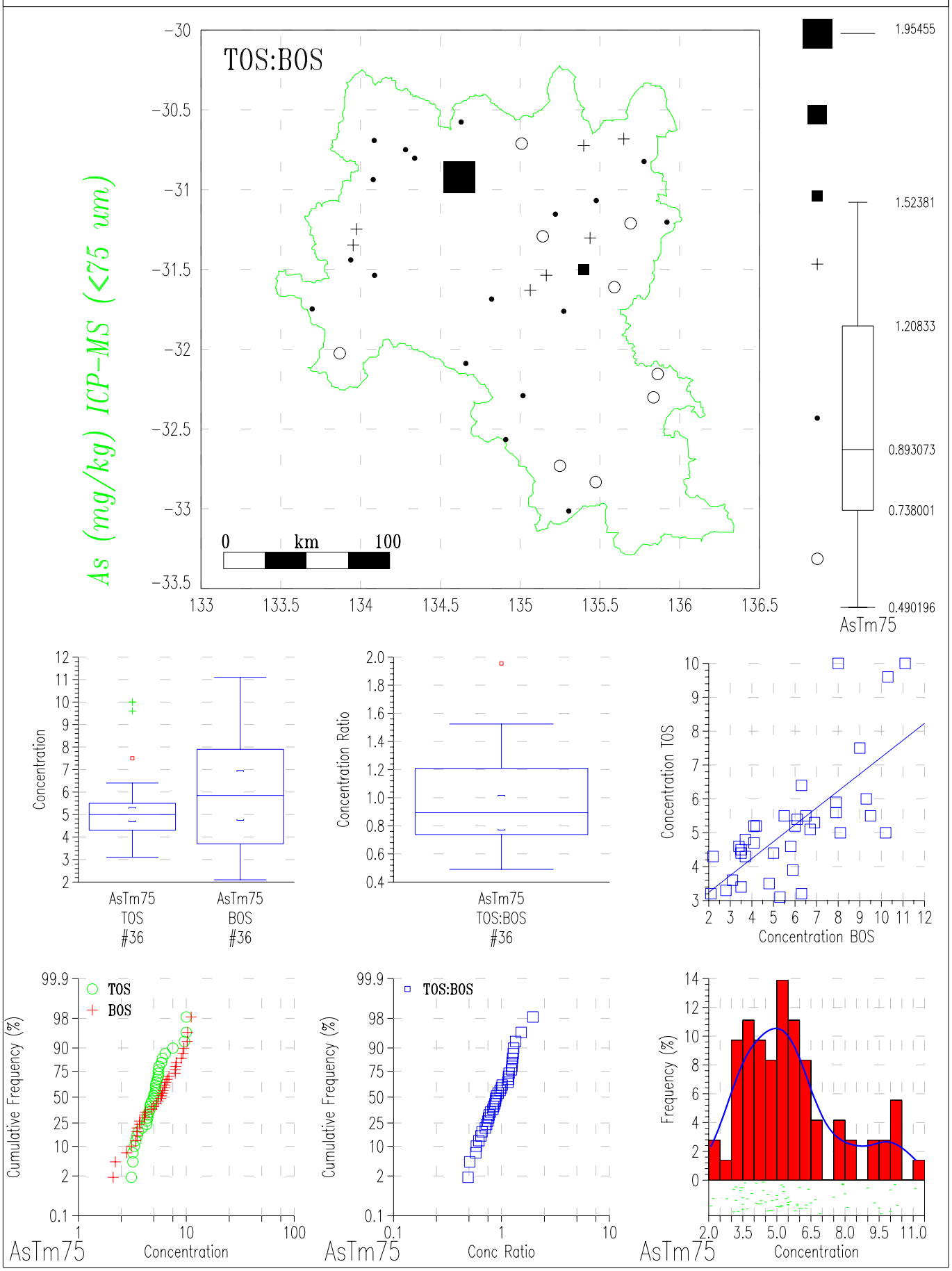
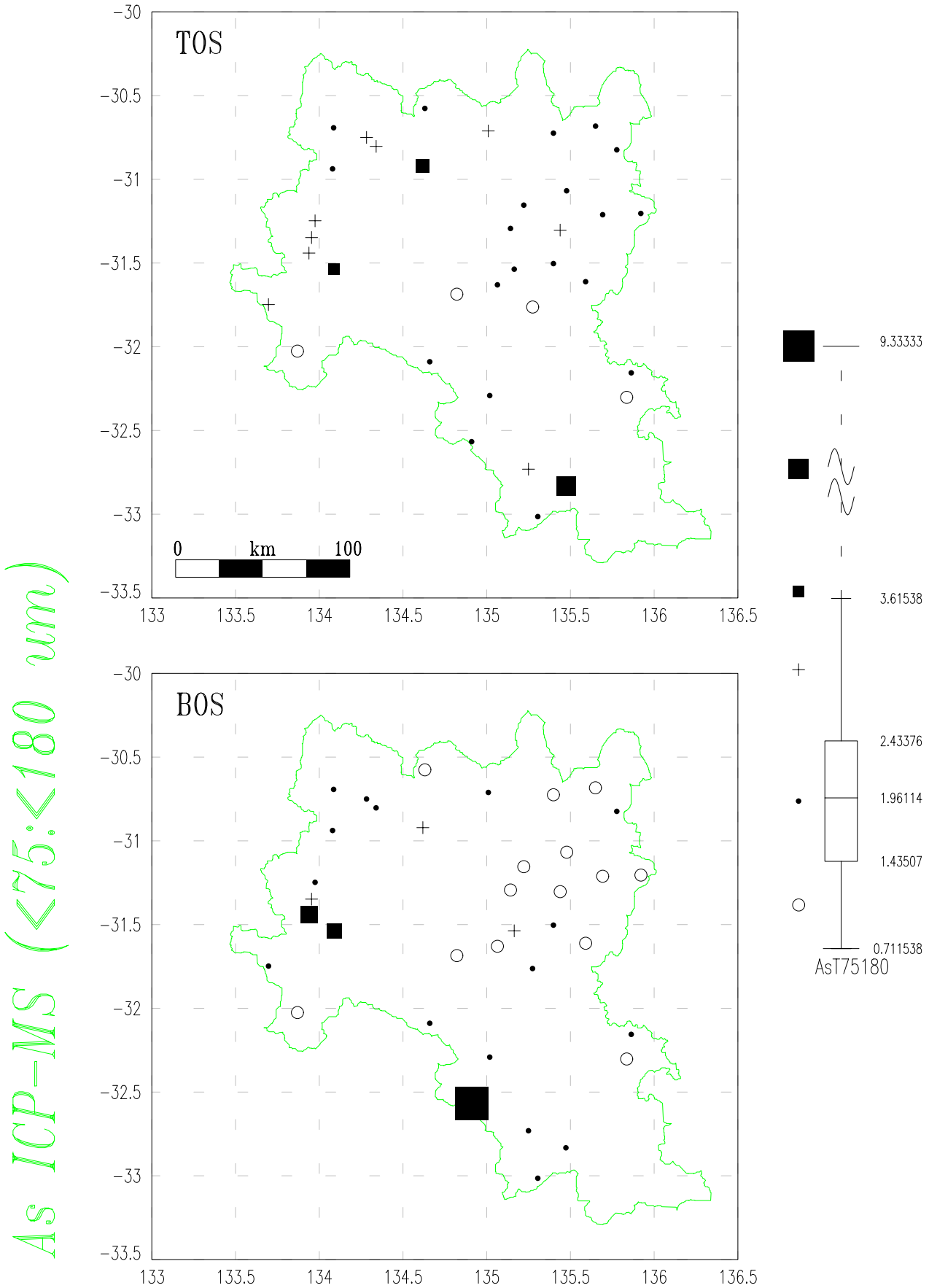
Top & Bottom Outlet Sediments (TOS & BOS)



GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



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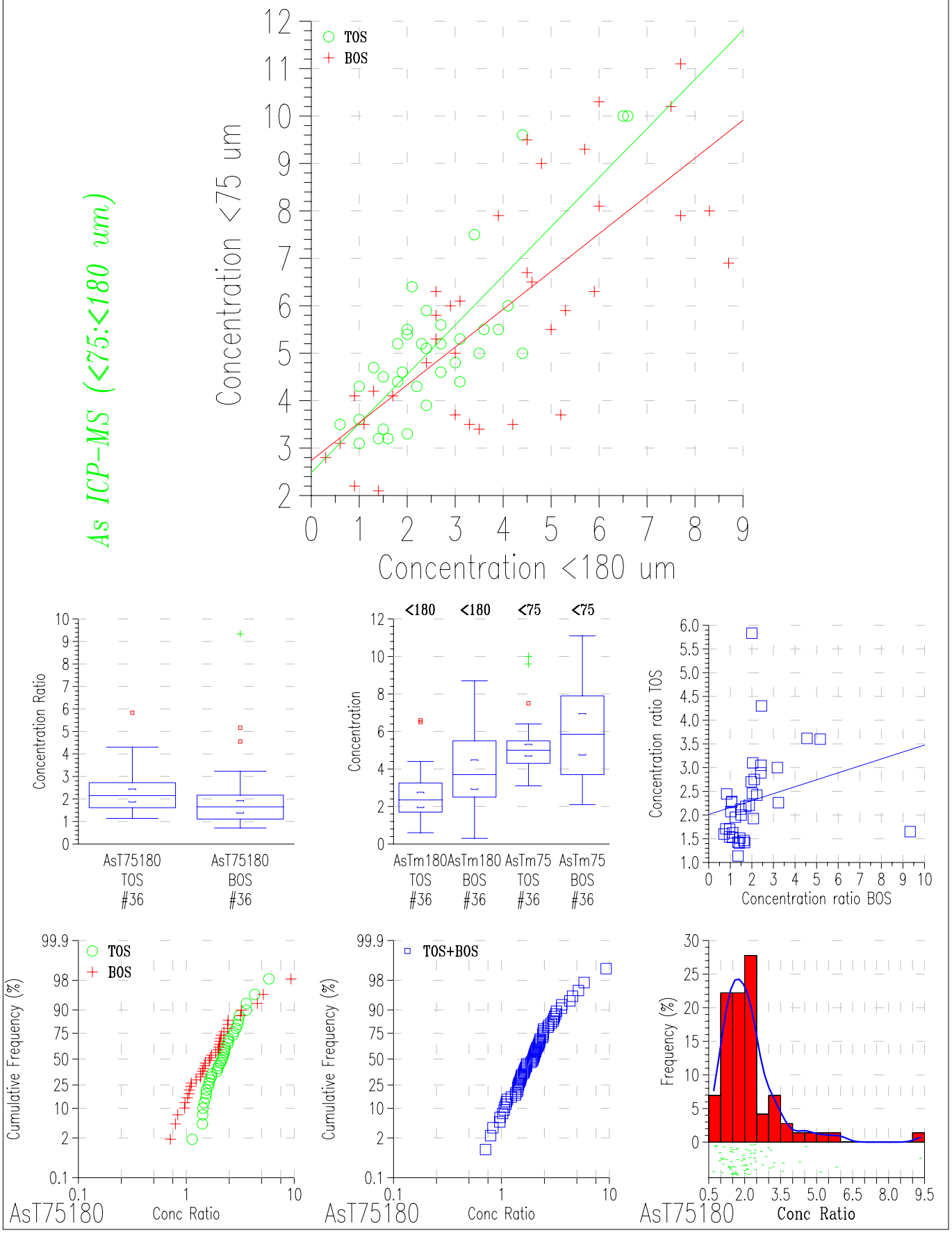
Top & Bottom Outlet Sediments (TOS & BOS)



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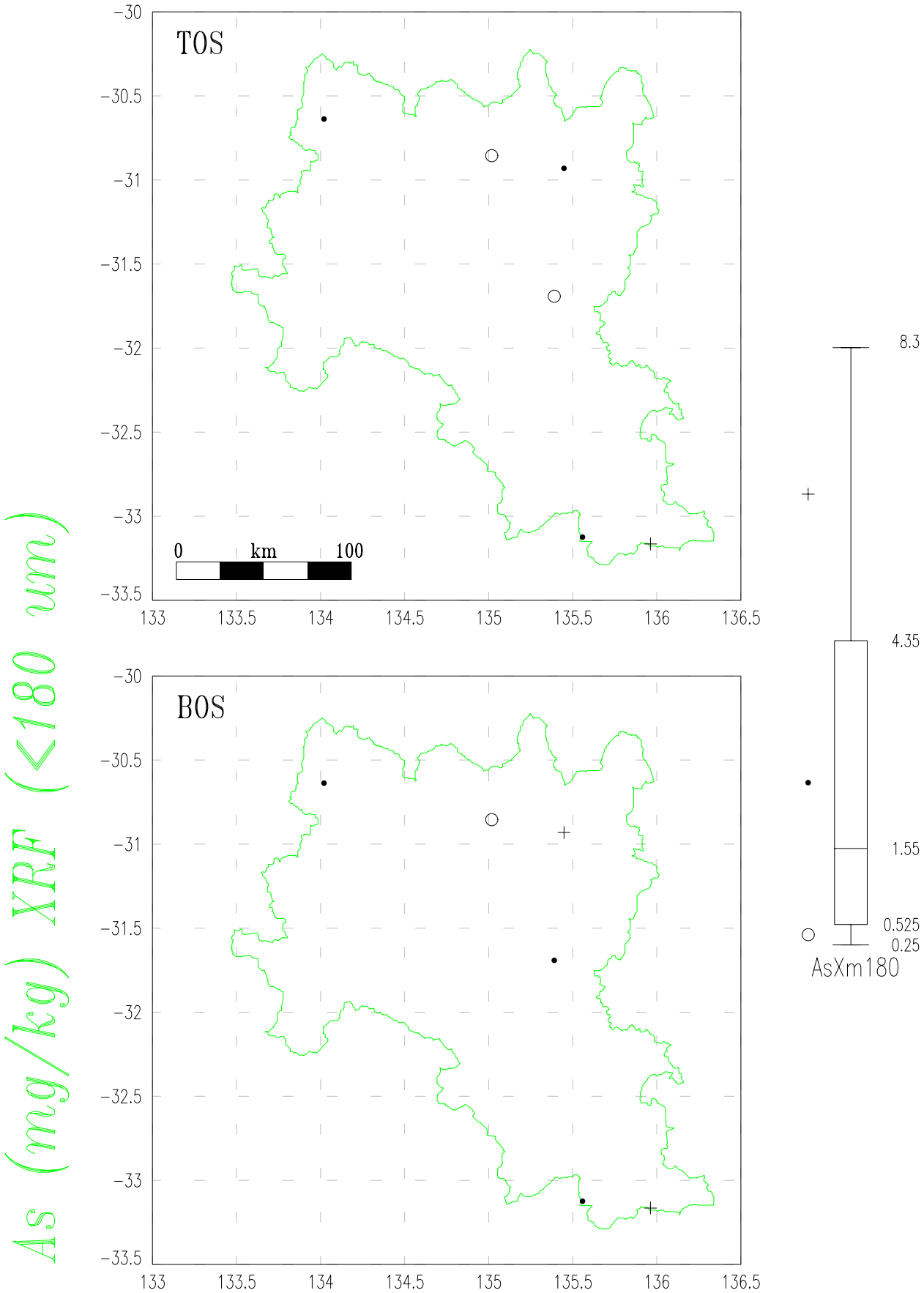
Top & Bottom Outlet Sediments (TOS & BOS)



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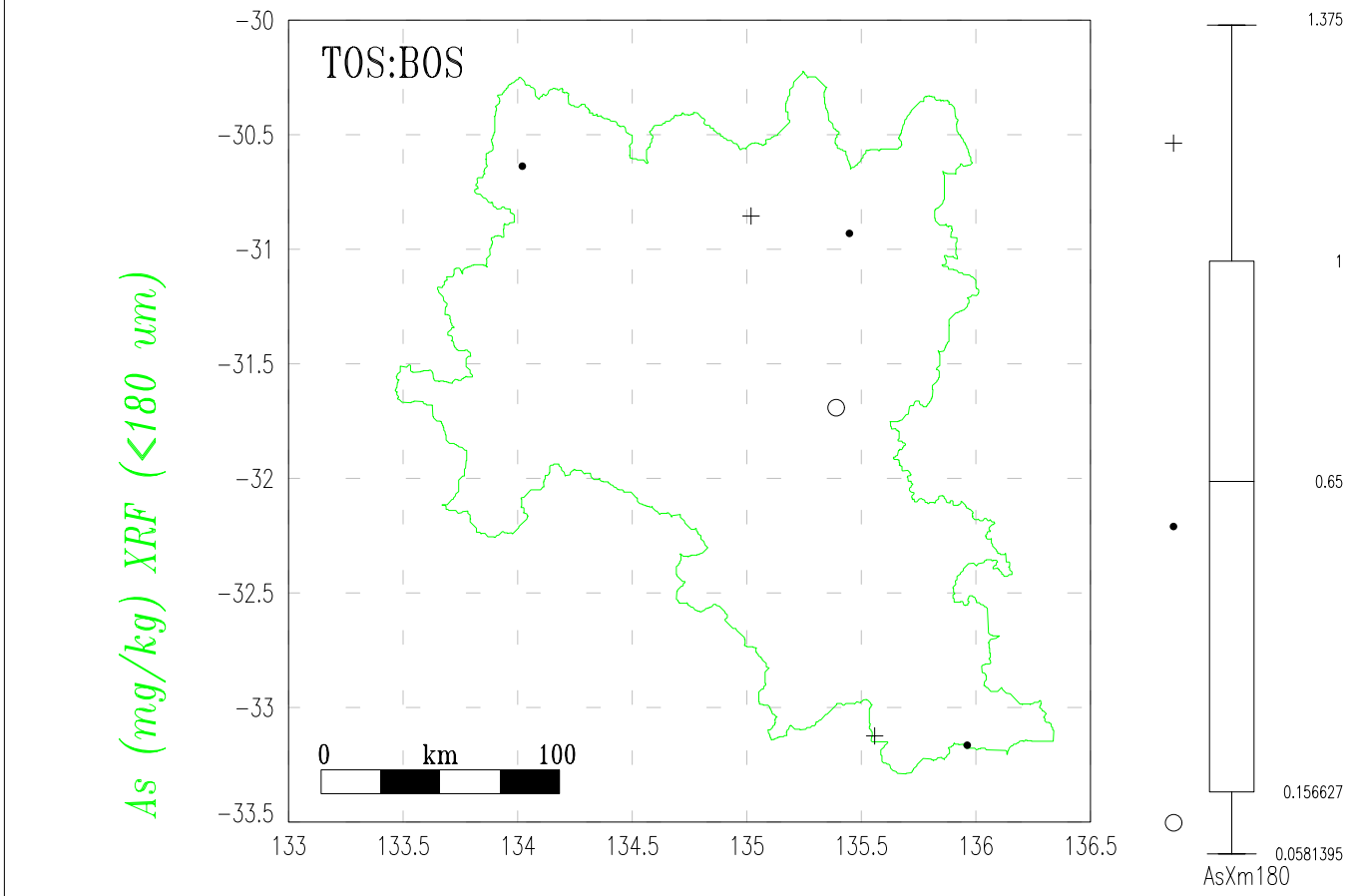
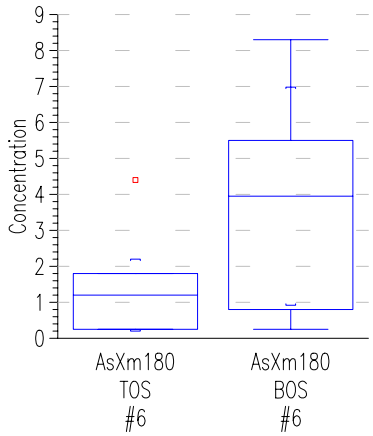
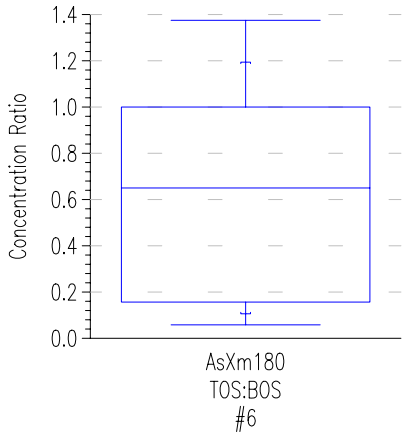
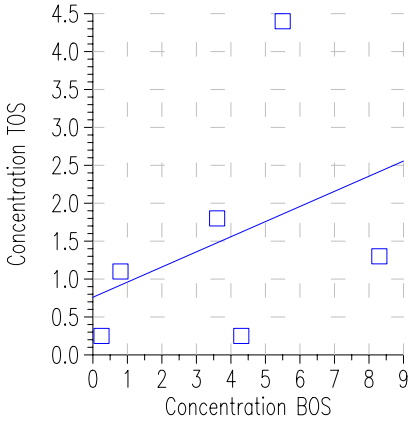
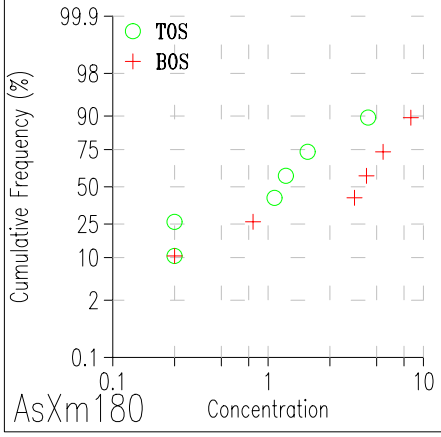
Top & Bottom Outlet Sediments (TOS & BOS)

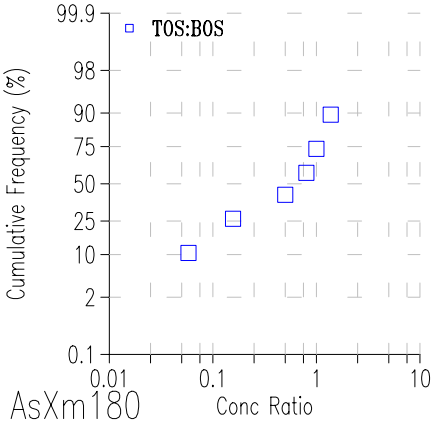


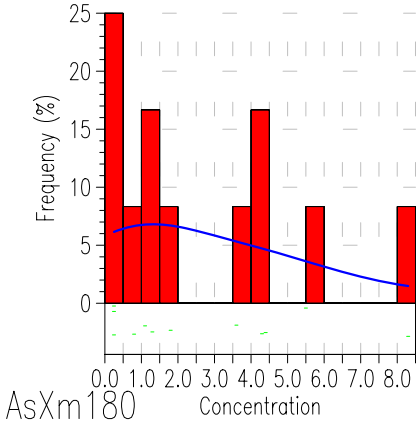






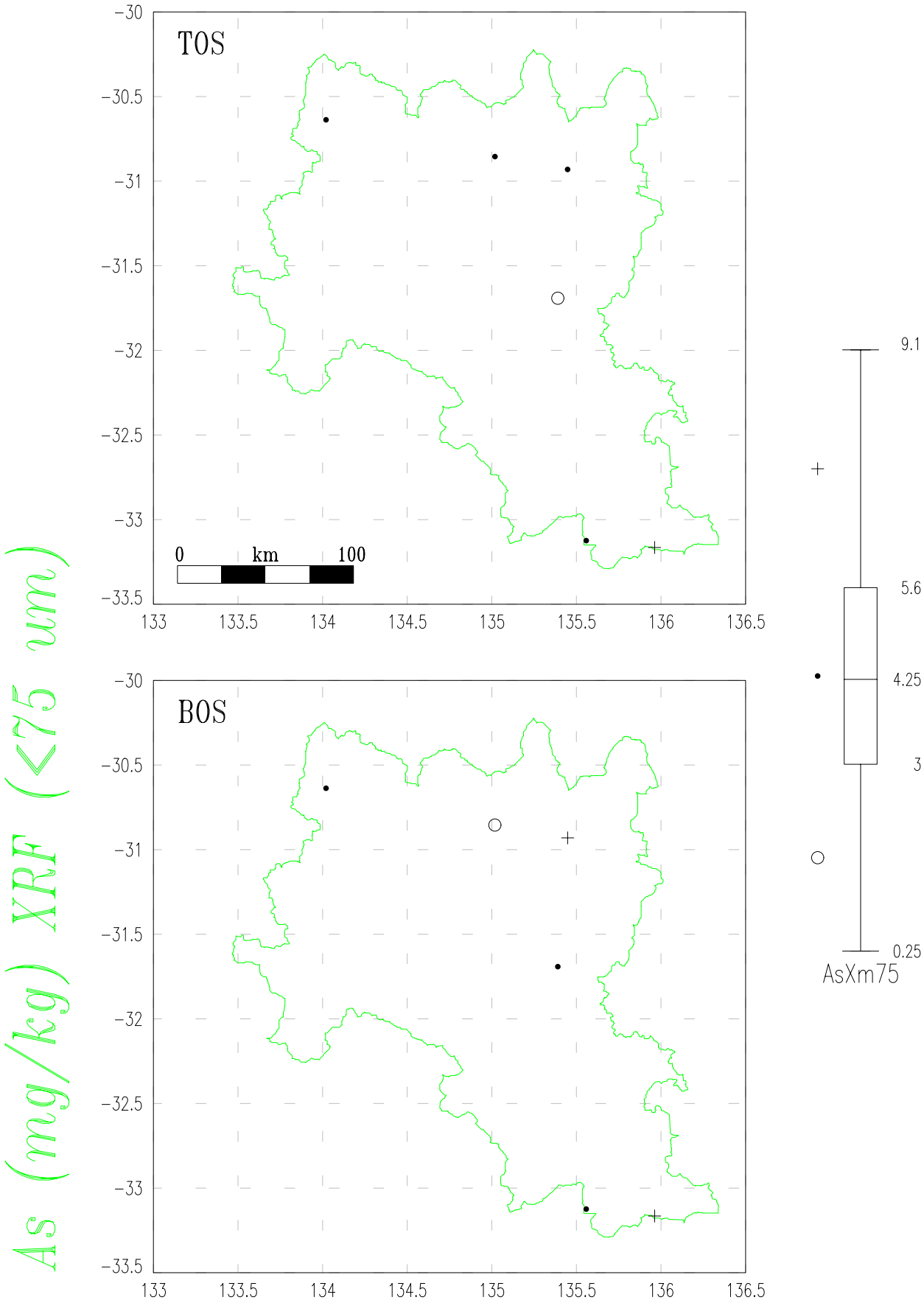






GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



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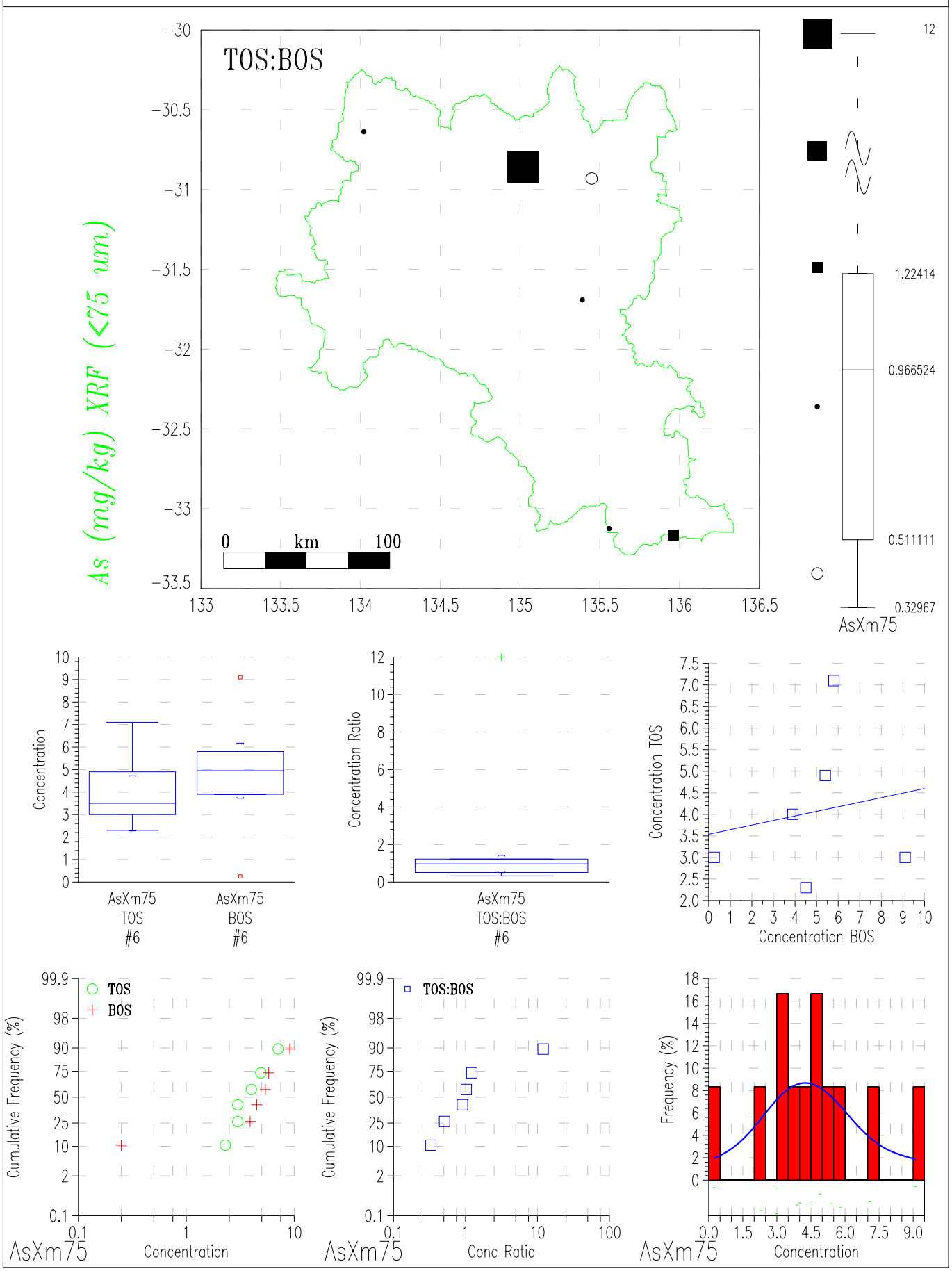
Top & Bottom Outlet Sediments (TOS & BOS)



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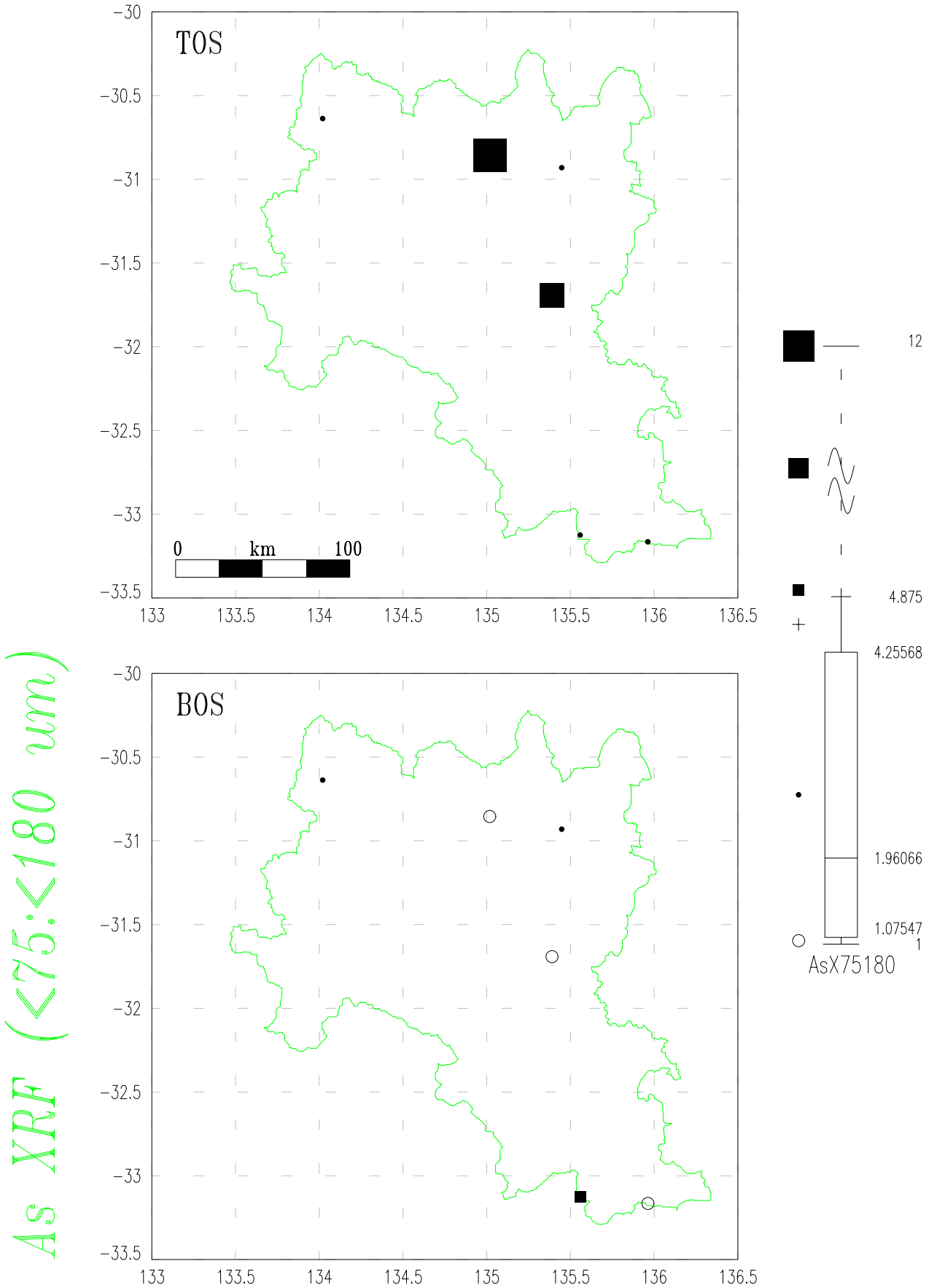
Top & Bottom Outlet Sediments (TOS & BOS)



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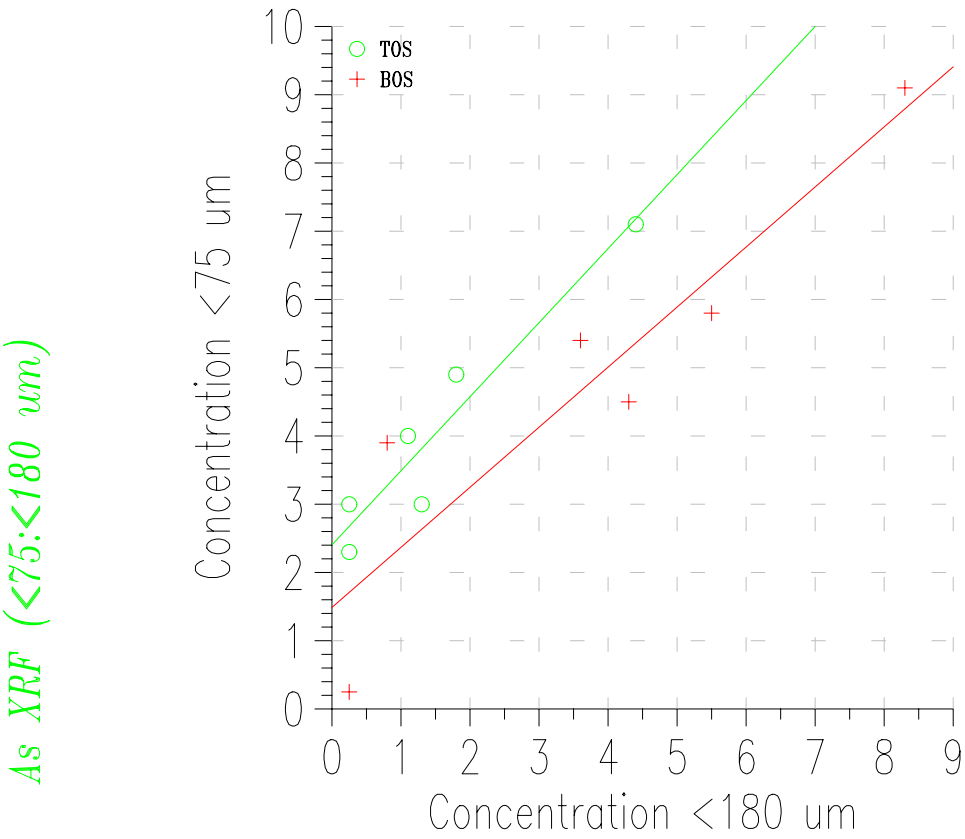
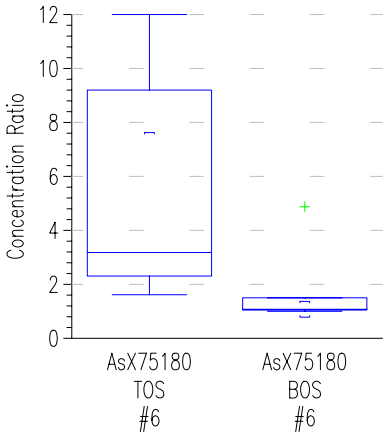
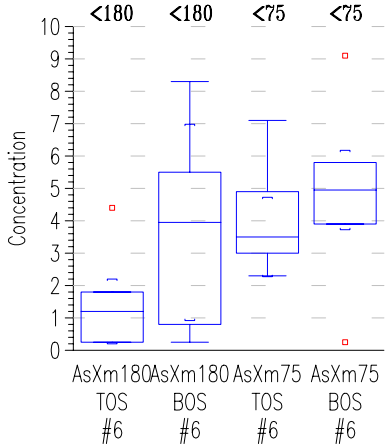
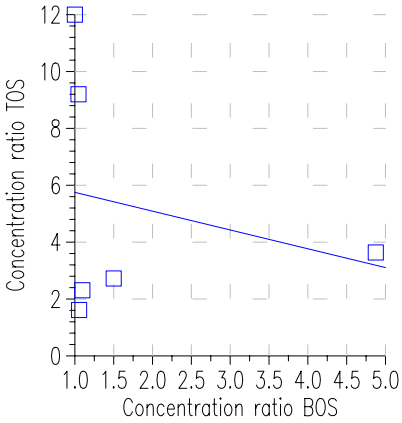
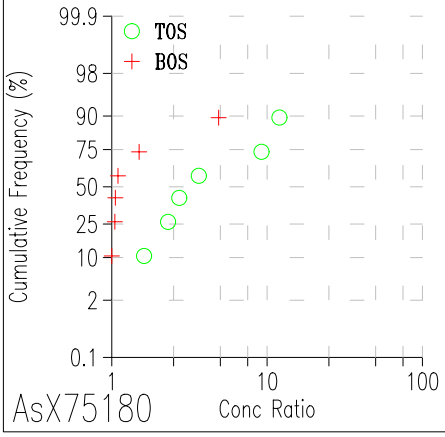
Top & Bottom Outlet Sediments (TOS & BOS)

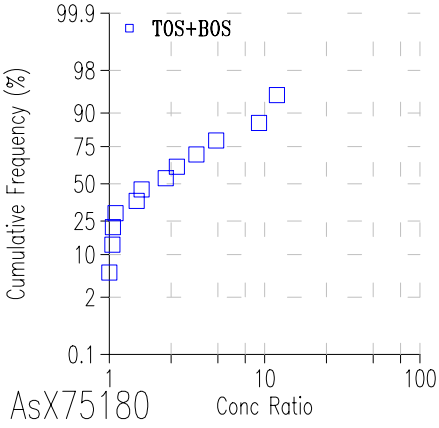


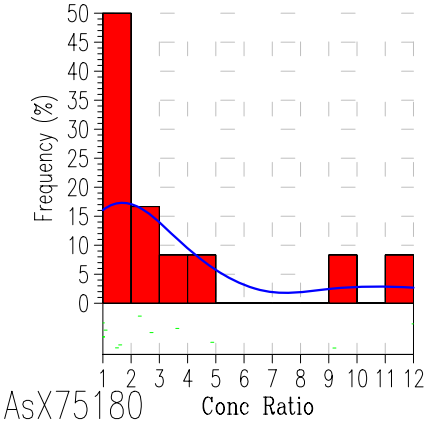






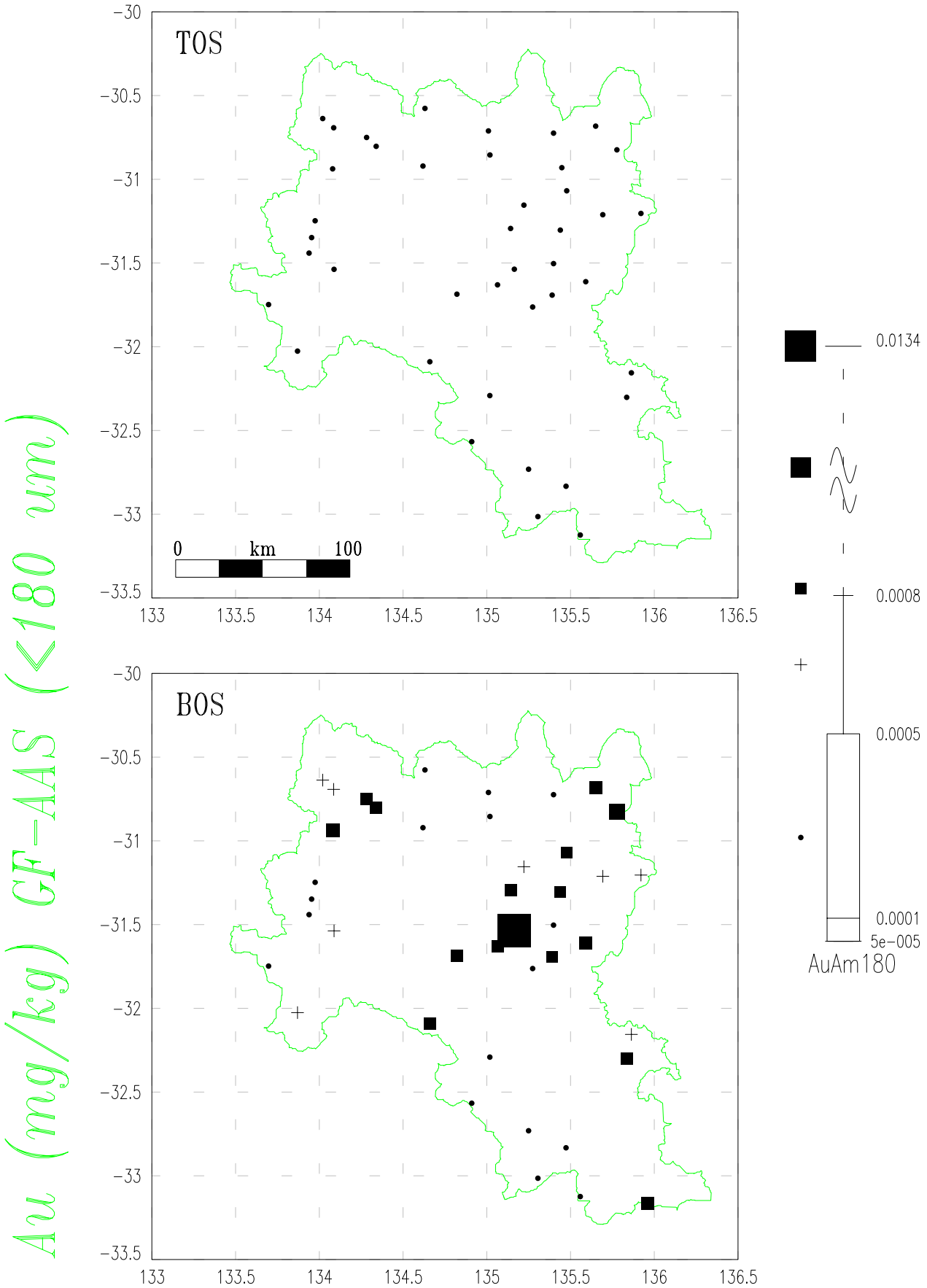






GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



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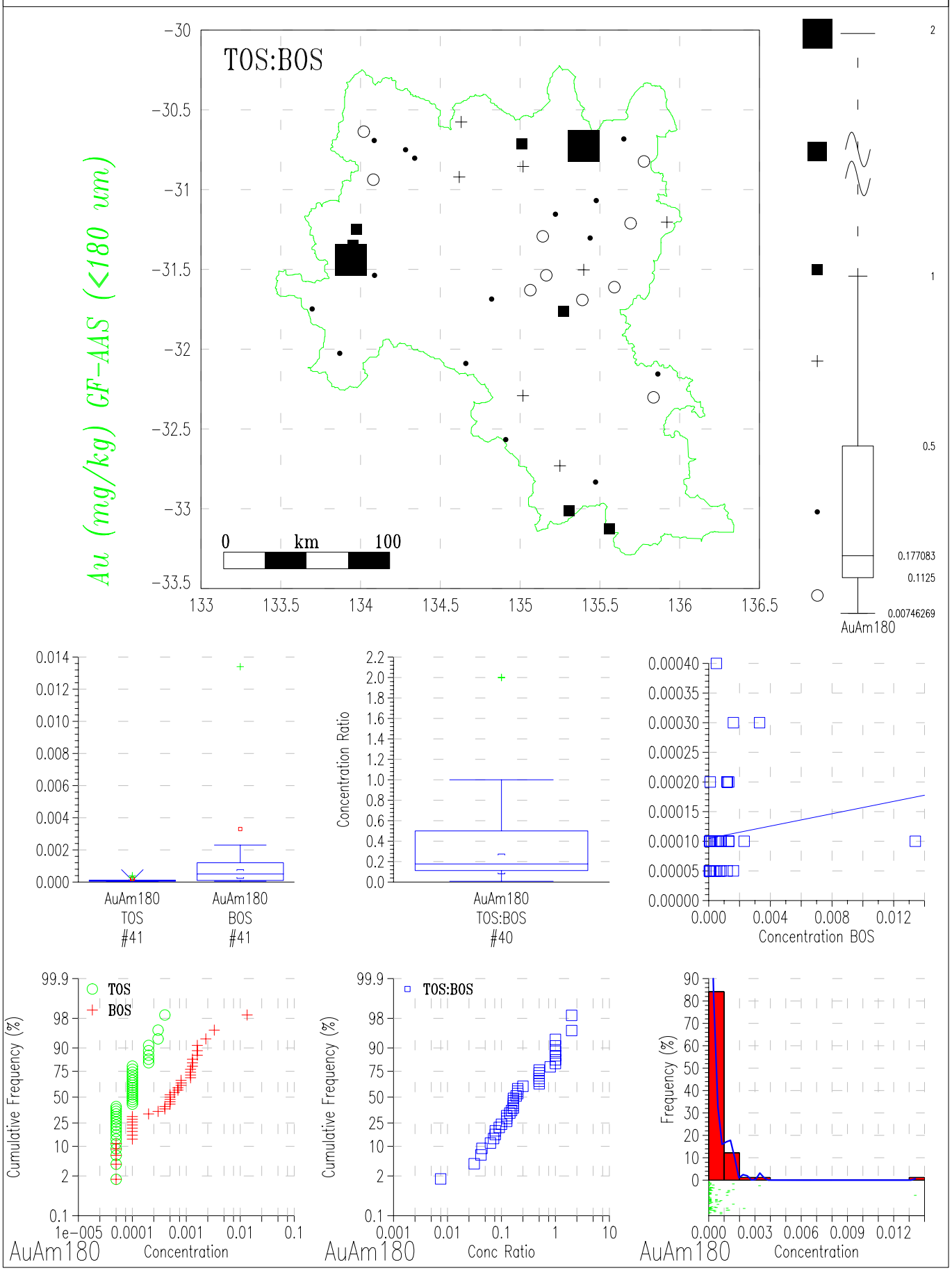
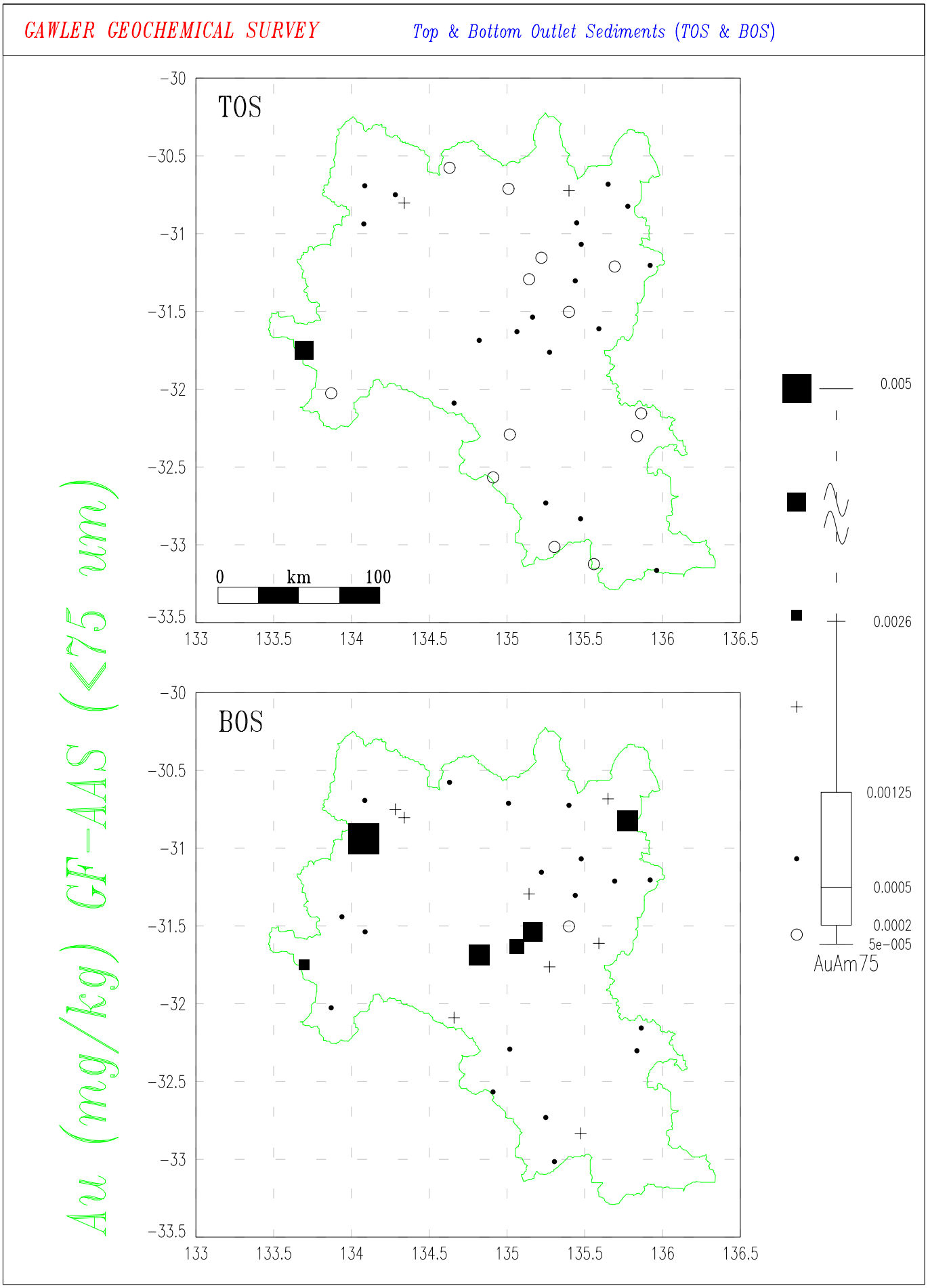
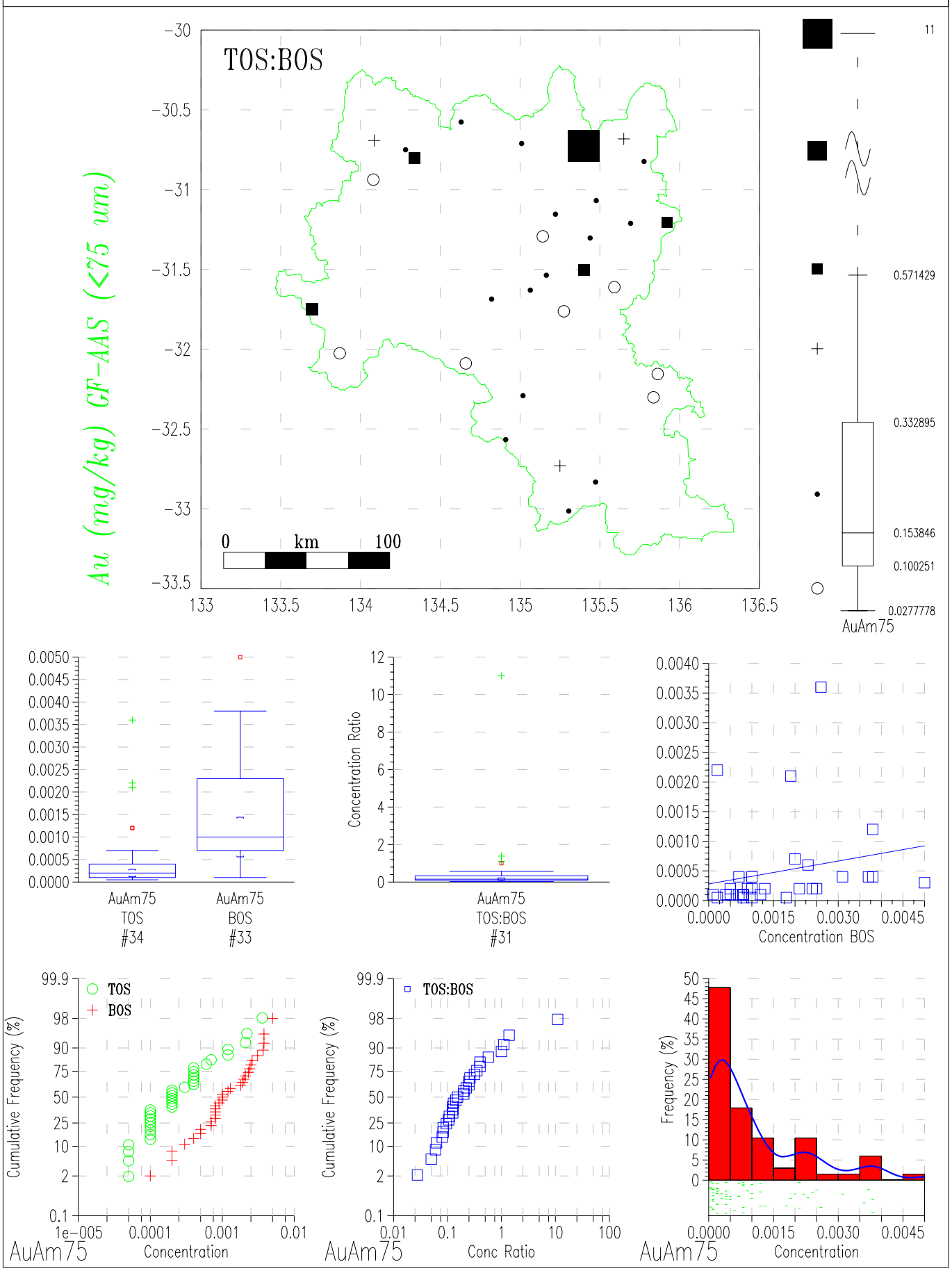
Top & Bottom Outlet Sediments (TOS & BOS)




GAWLER GEOCHEMICAL SURVEY
Top & Bottom Outlet Sediments (TOS & BOS)
Au (mg/kg) GF-AAS (<75 um)
TOS
BOS
0 km 100
-30
-30.5
-31
-31.5
-32
-32.5
-33
-33.5
133
133.5
134
134.5
135
135.5
136
136.5
0.005
0.0026
0.00125
0.0005
0.0002
5e-005
AuAm75

GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



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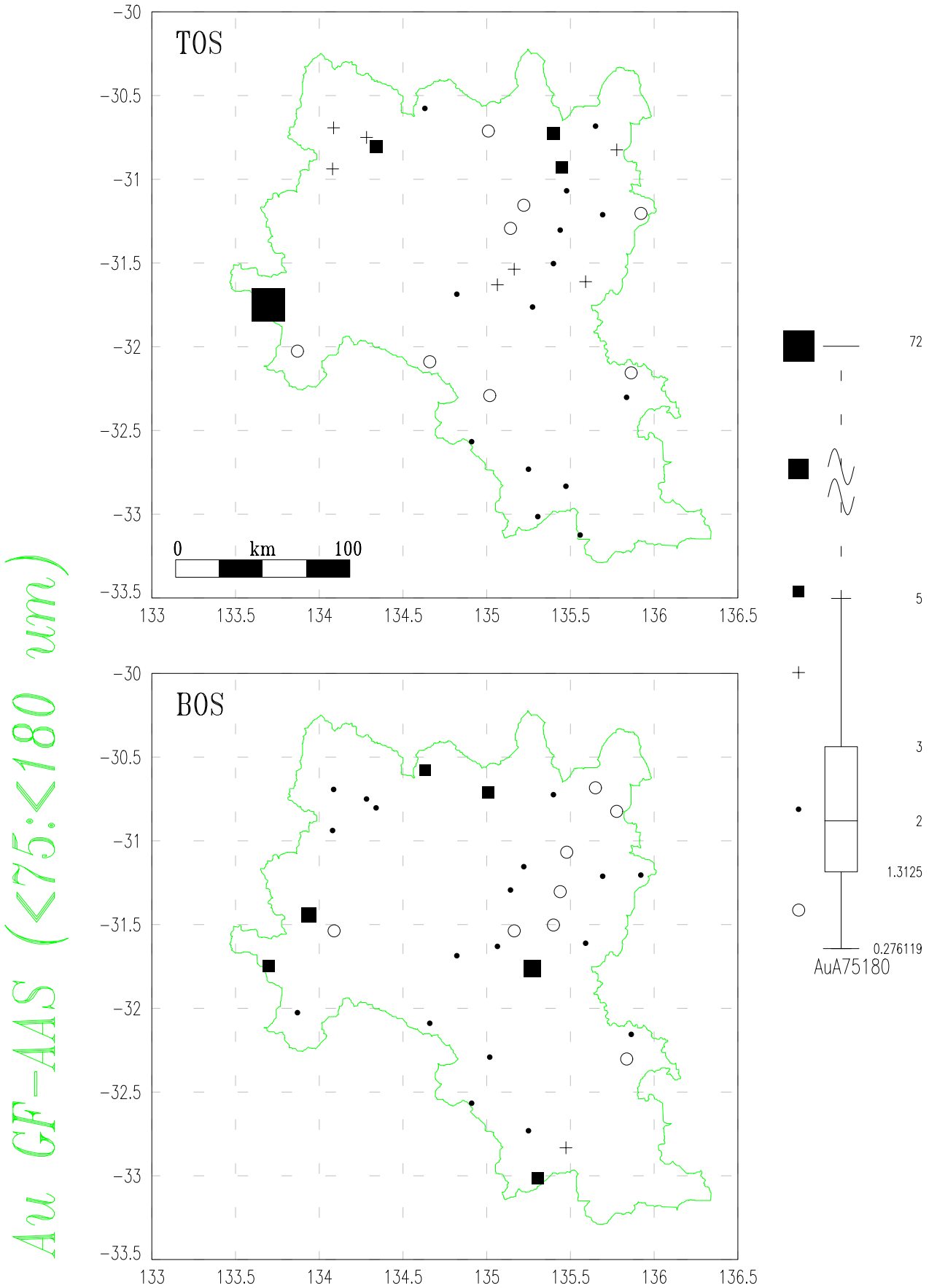
Top & Bottom Outlet Sediments (TOS & BOS)



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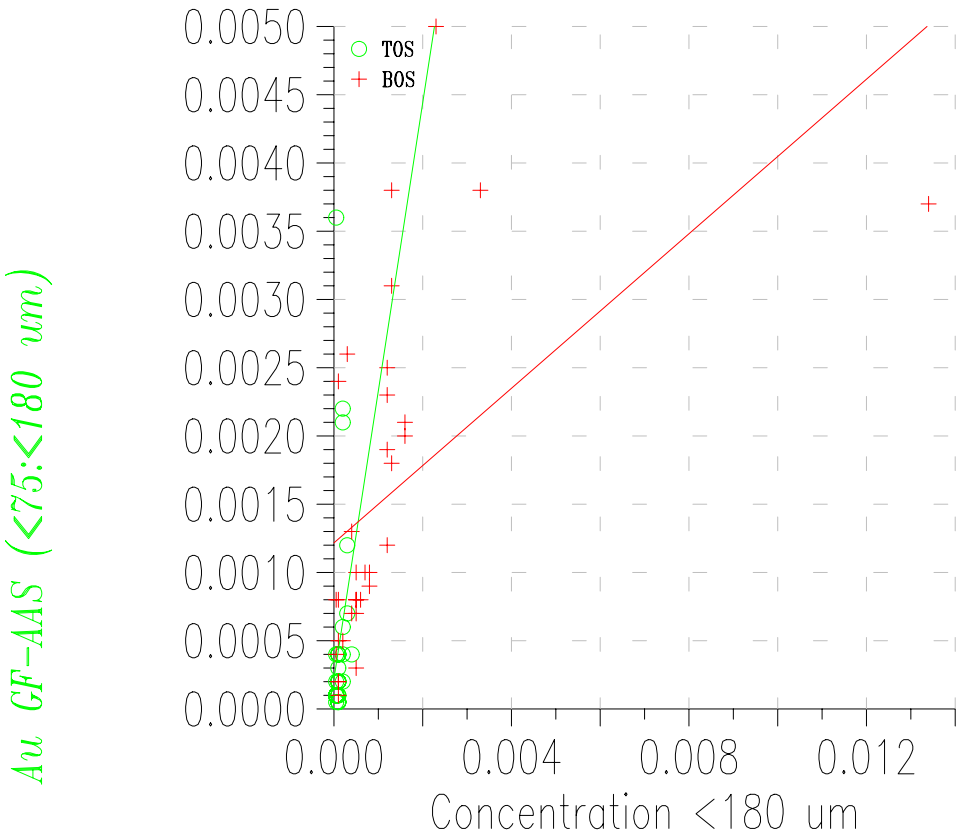
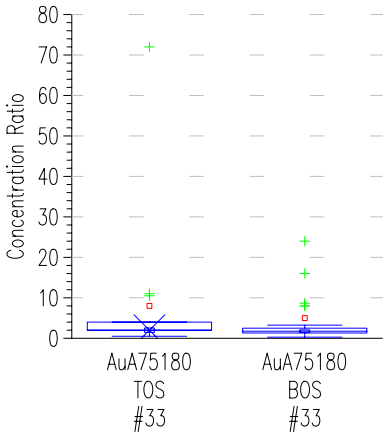
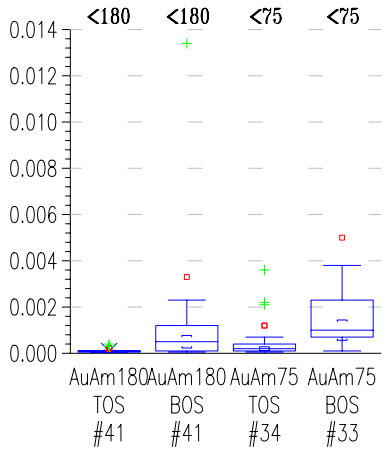
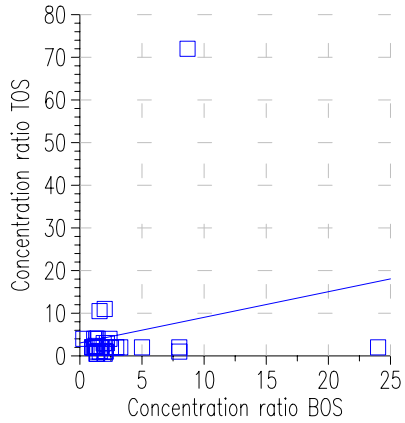
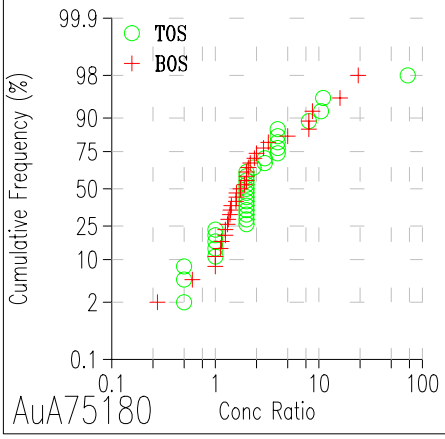
Top & Bottom Outlet Sediments (TOS & BOS)

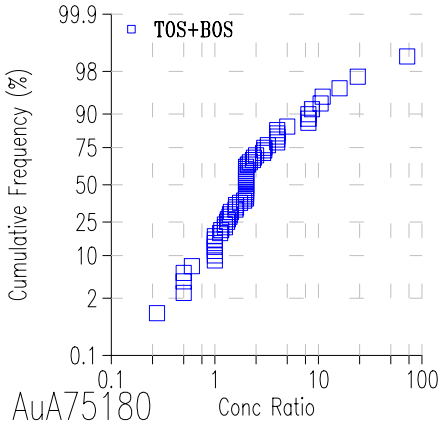


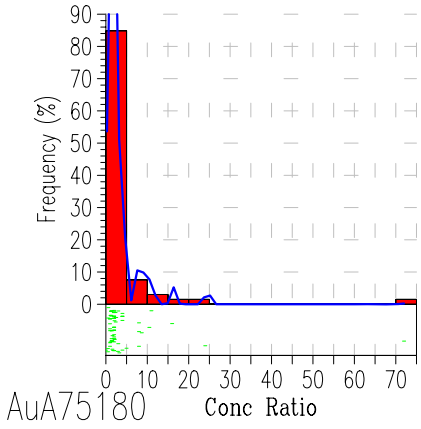








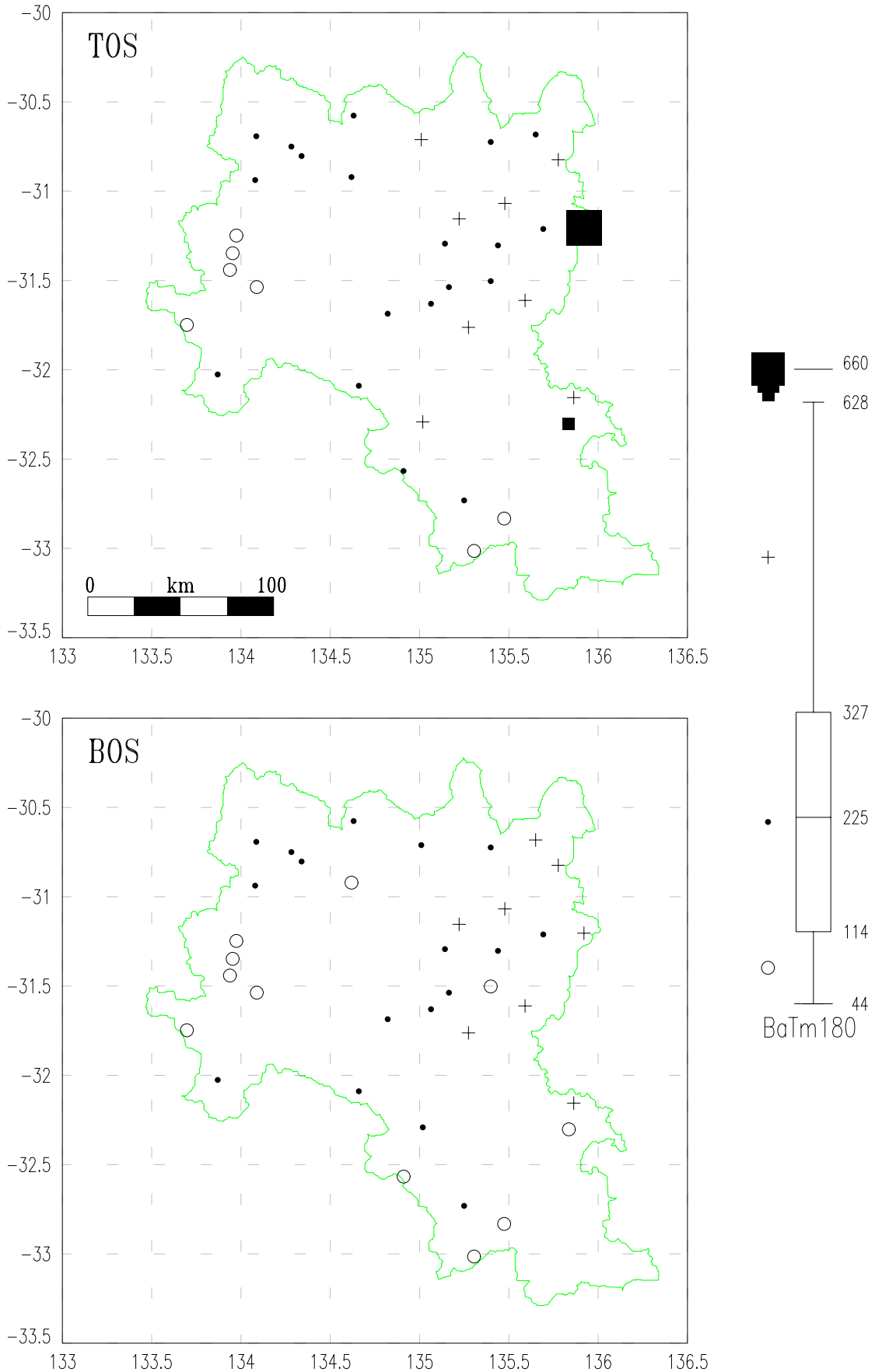




GAWLER GEOCHEMICAL SURVEY

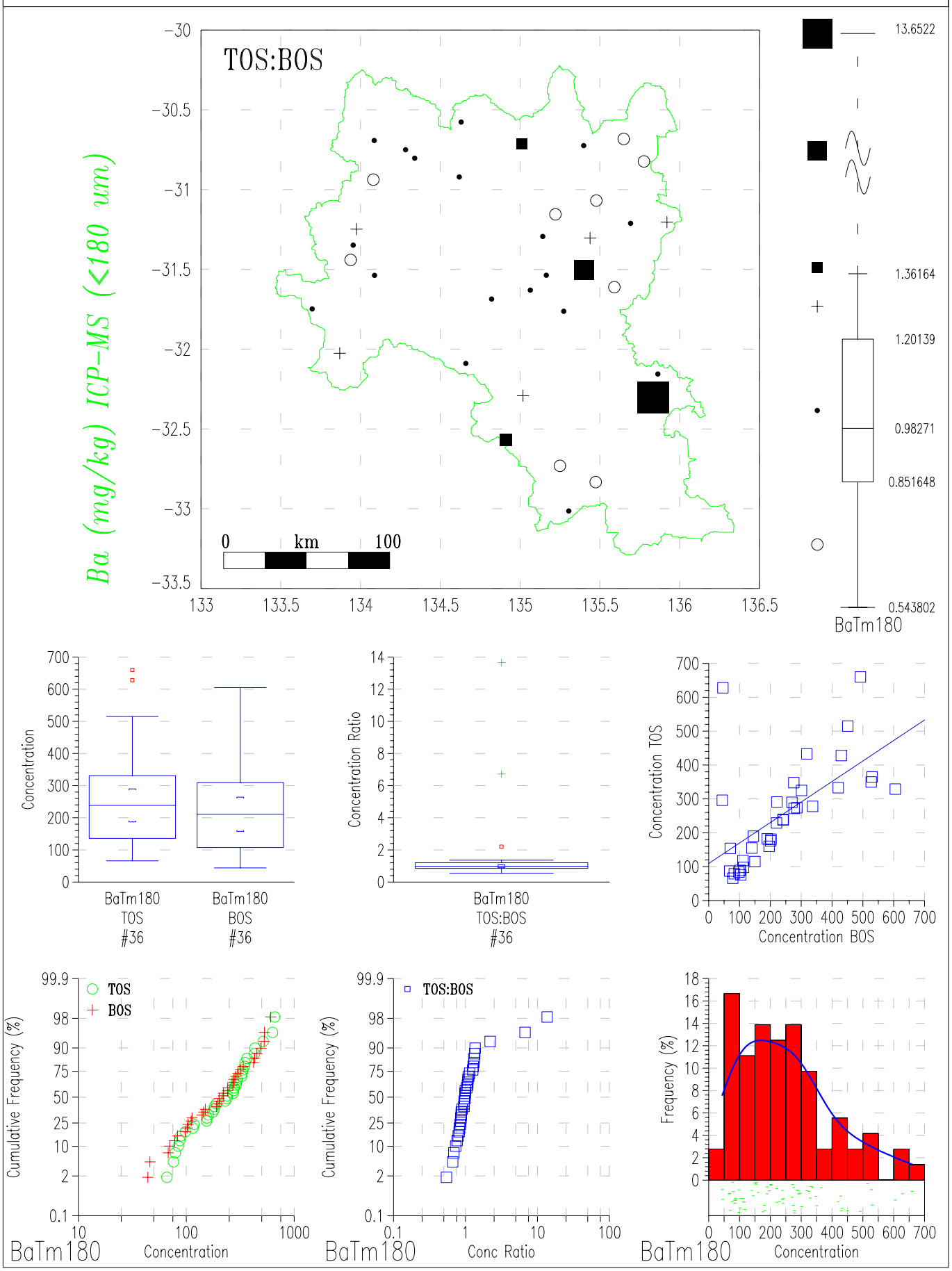
Top & Bottom Outlet Sediments (TOS & BOS)

Ba (mg/kg) ICP-MS (<180 um)



GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



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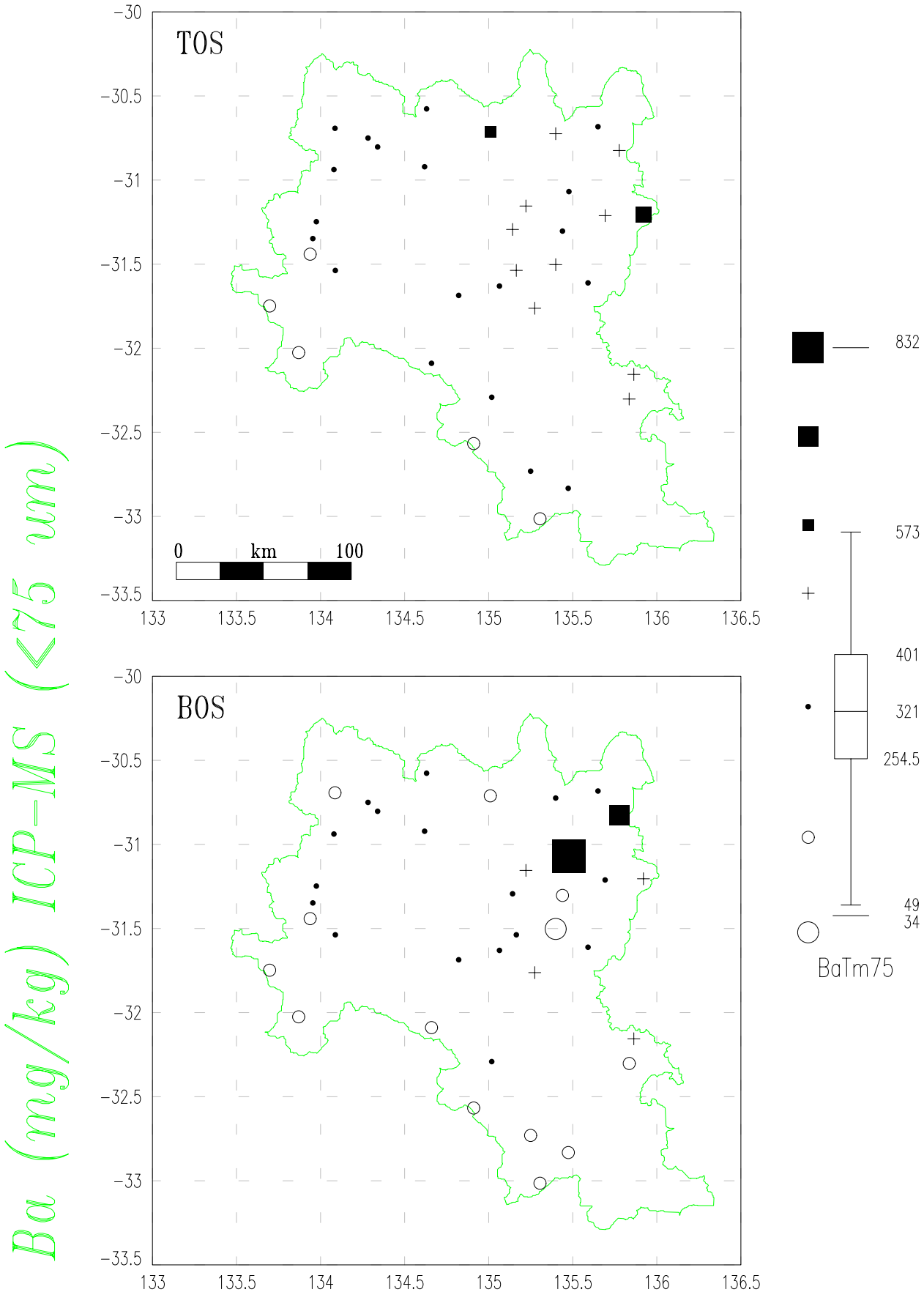
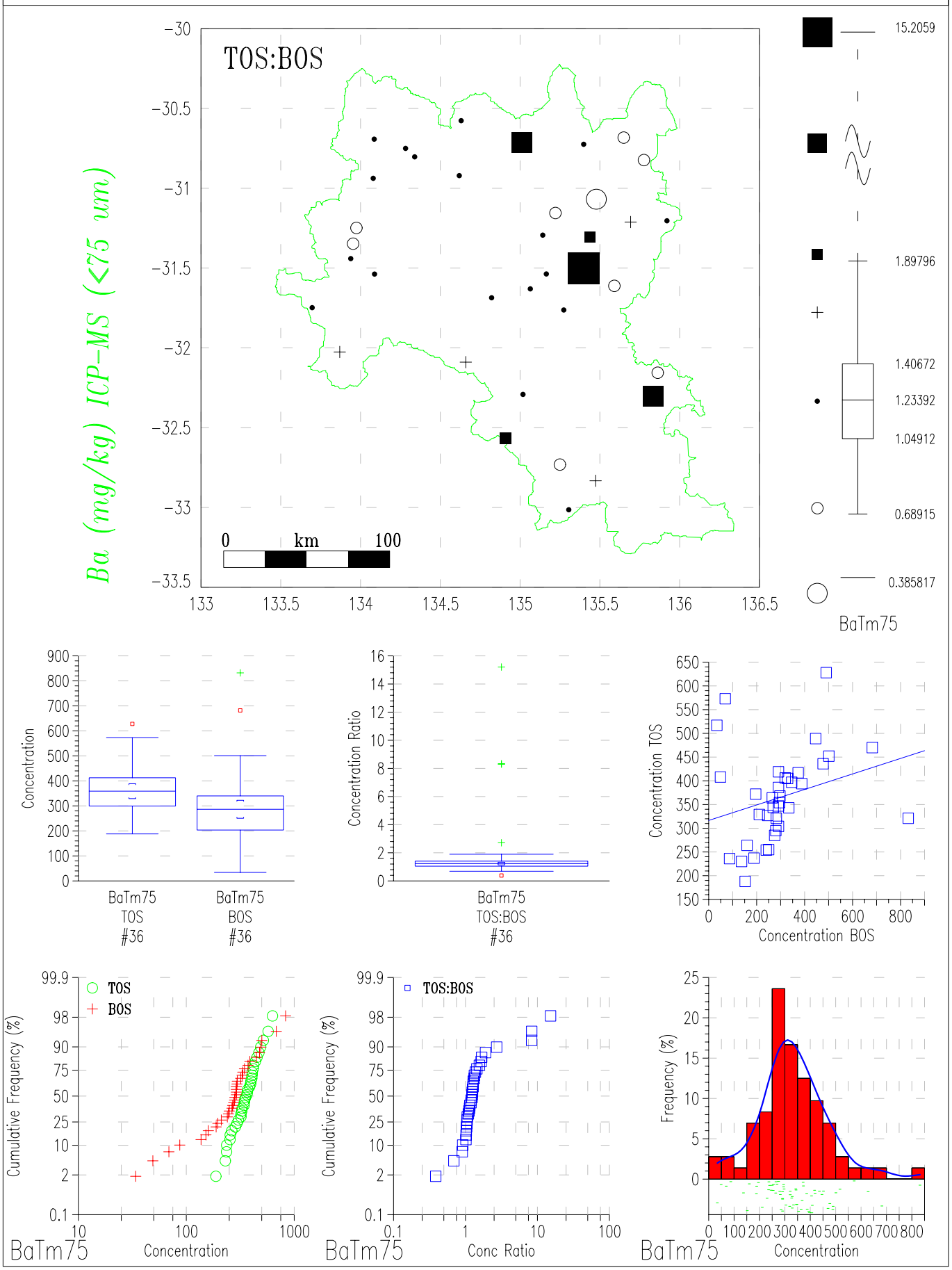
Top & Bottom Outlet Sediments (TOS & BOS)



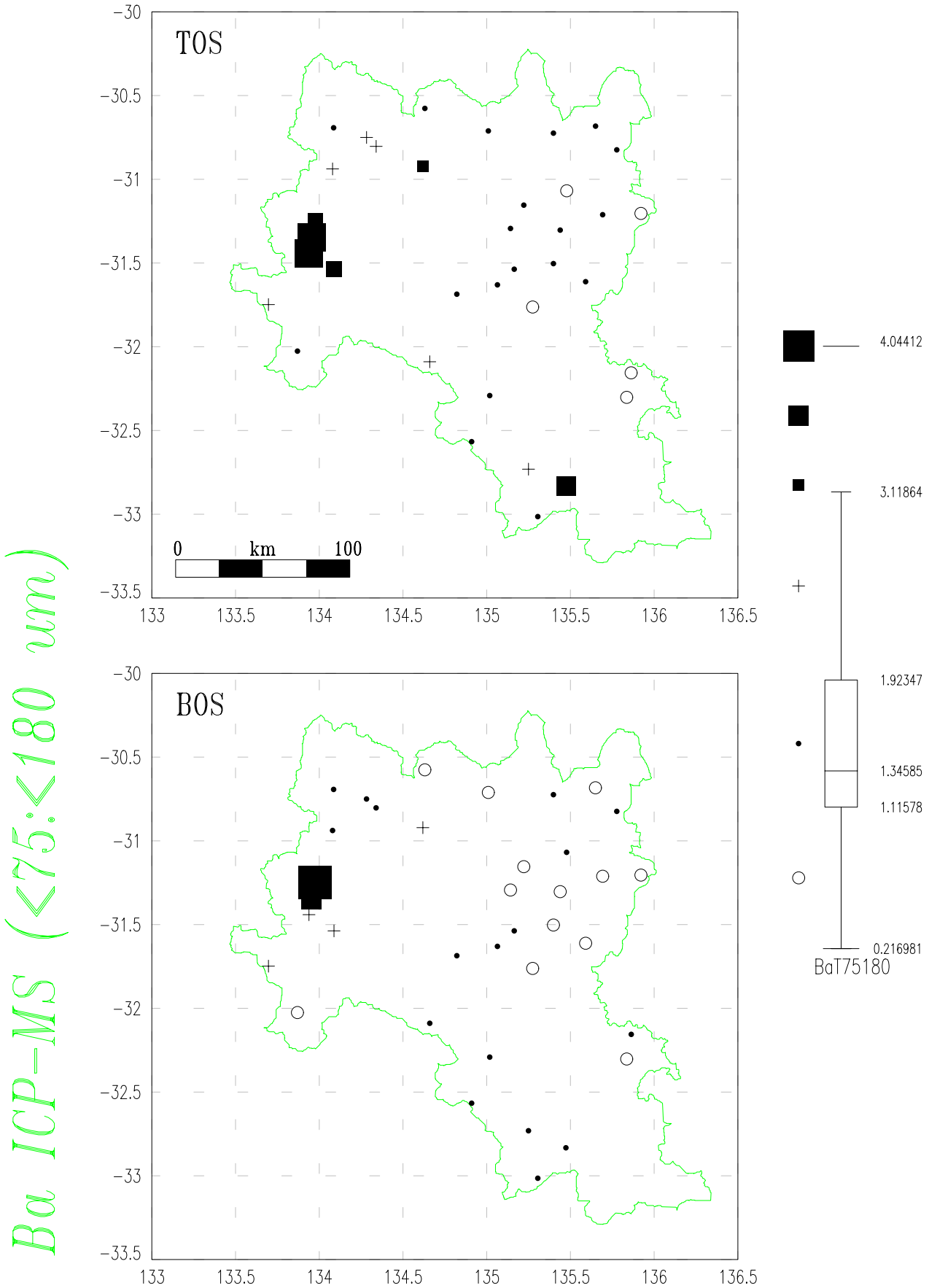
GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



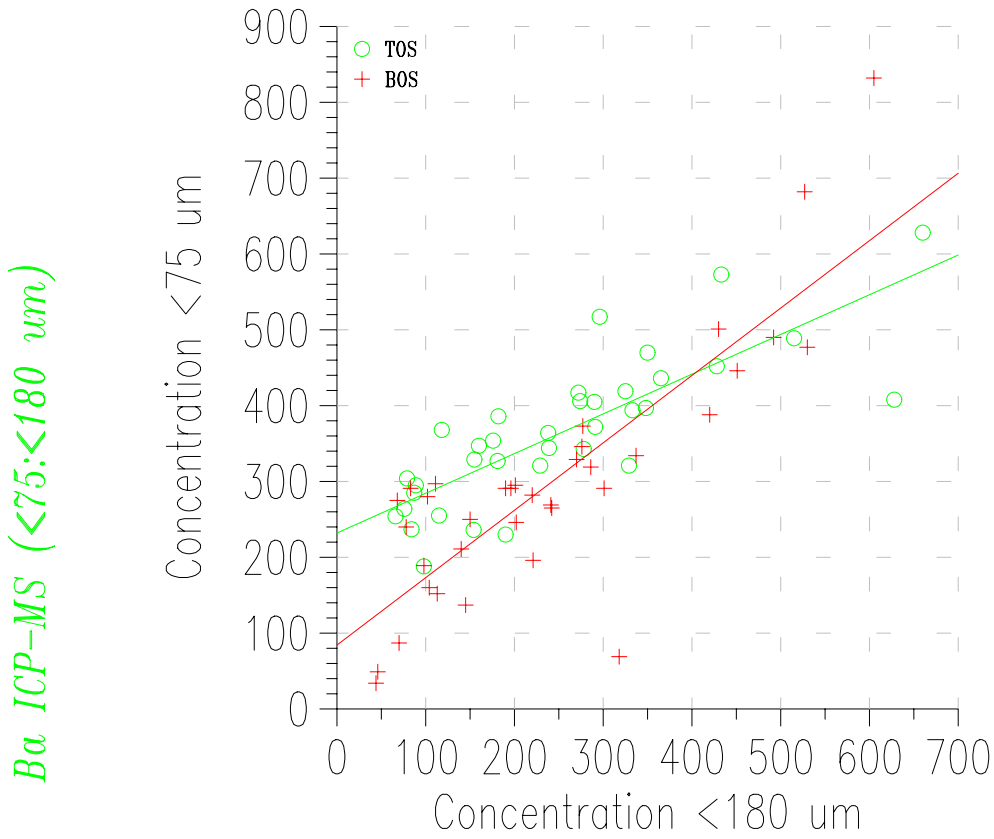
GAWLER GEOCHEMICAL SURVEY

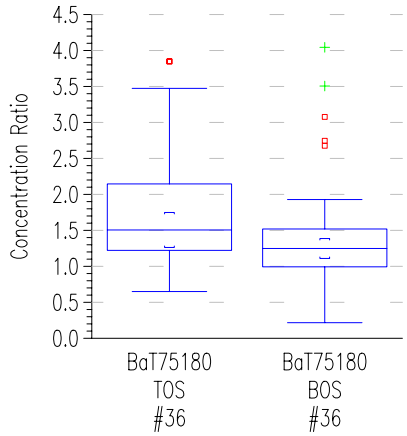
Top & Bottom Outlet Sediments (TOS & BOS)

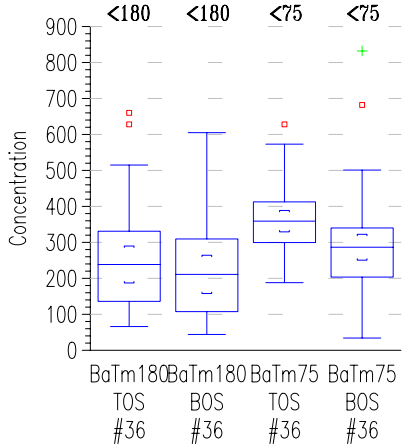


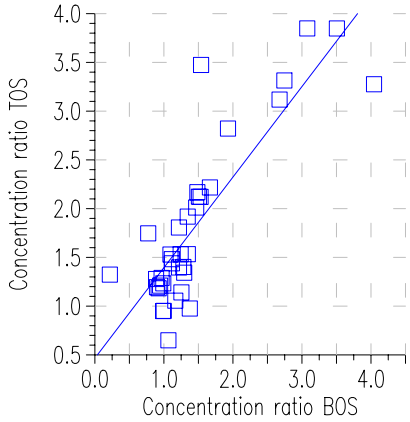
GAWLER GEOCHEMICAL SURVEY

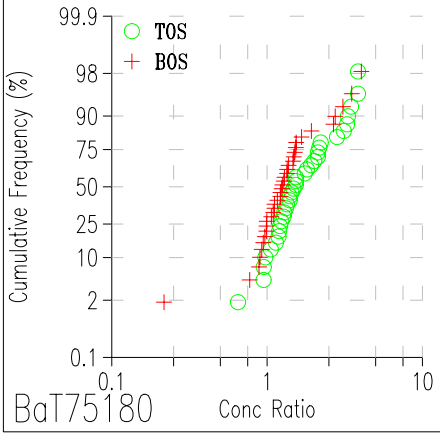
Top & Bottom Outlet Sediments (TOS & BOS)

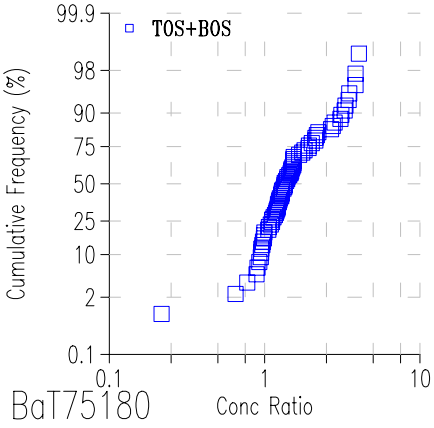


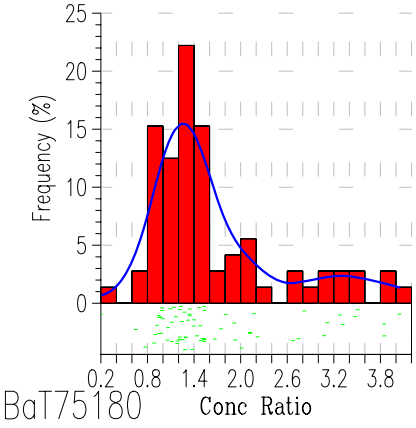






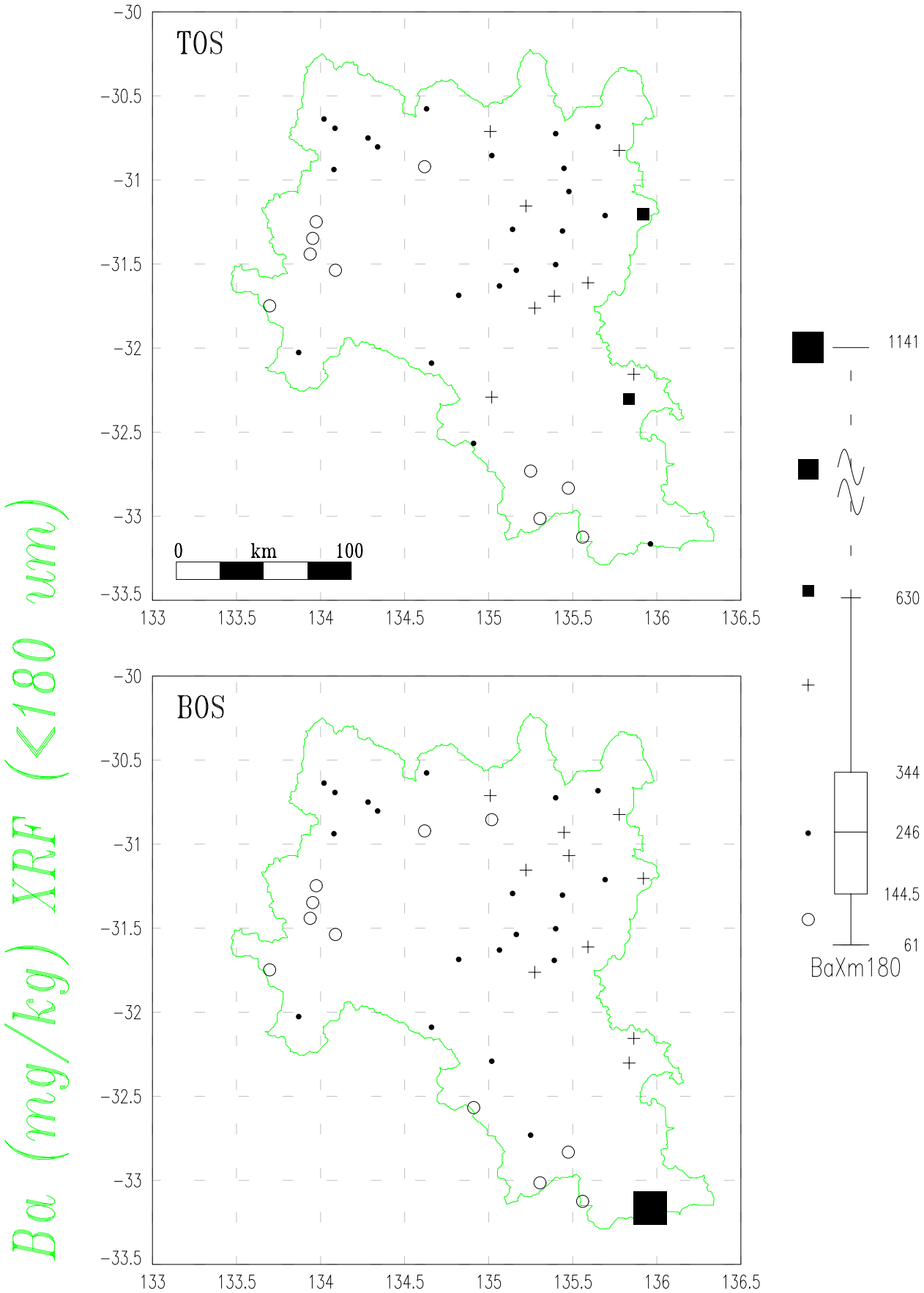






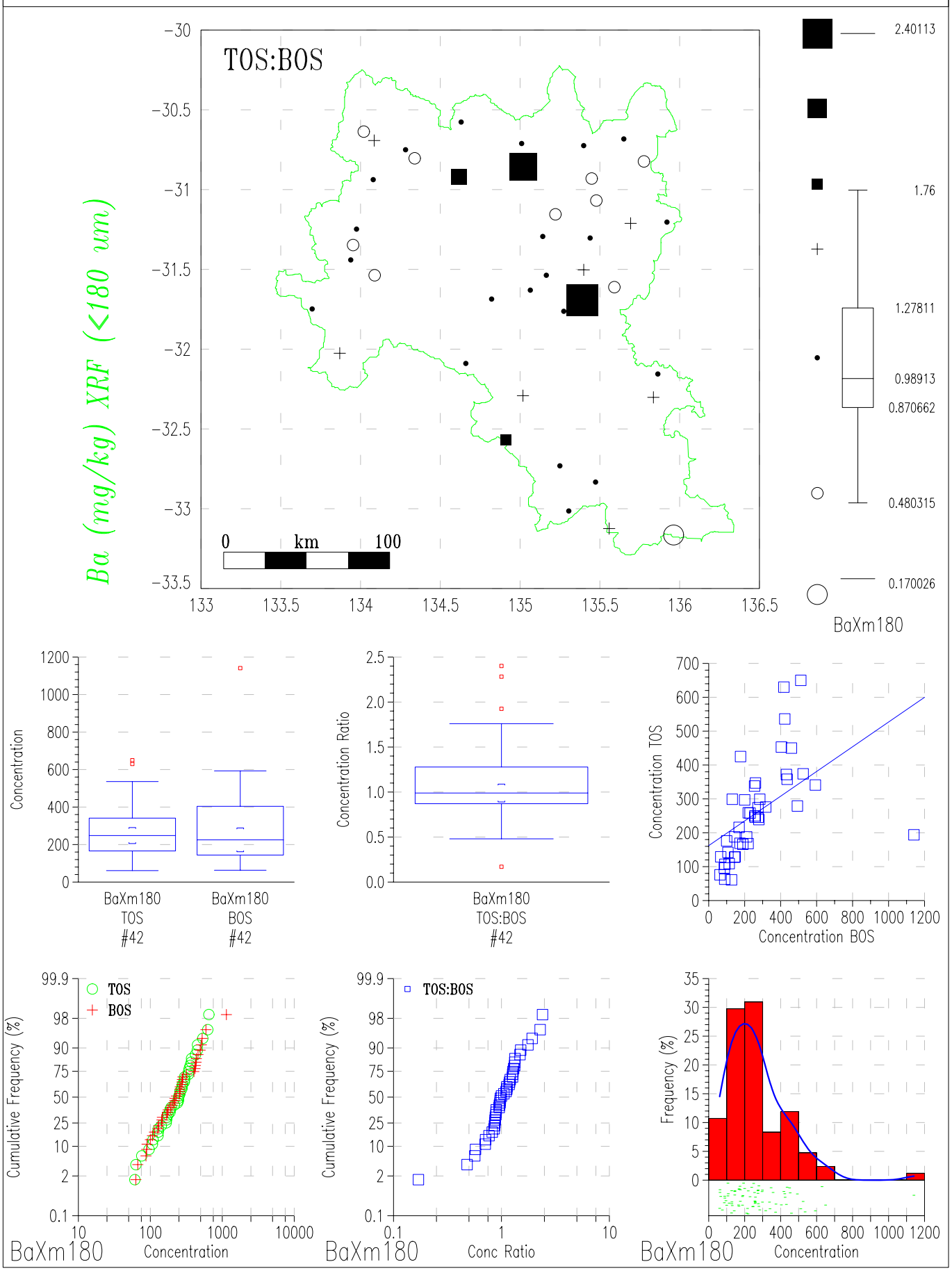
GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



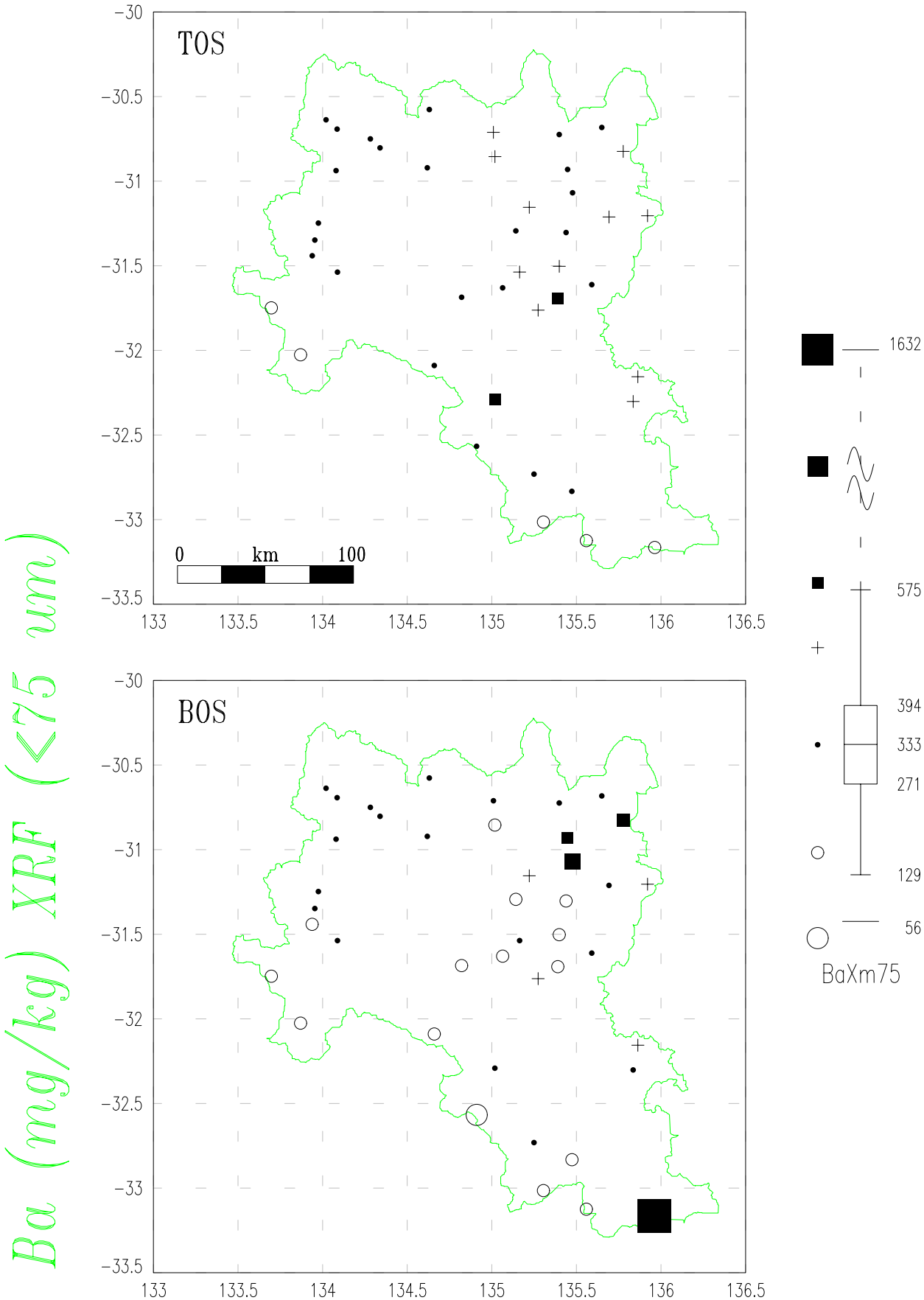
GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



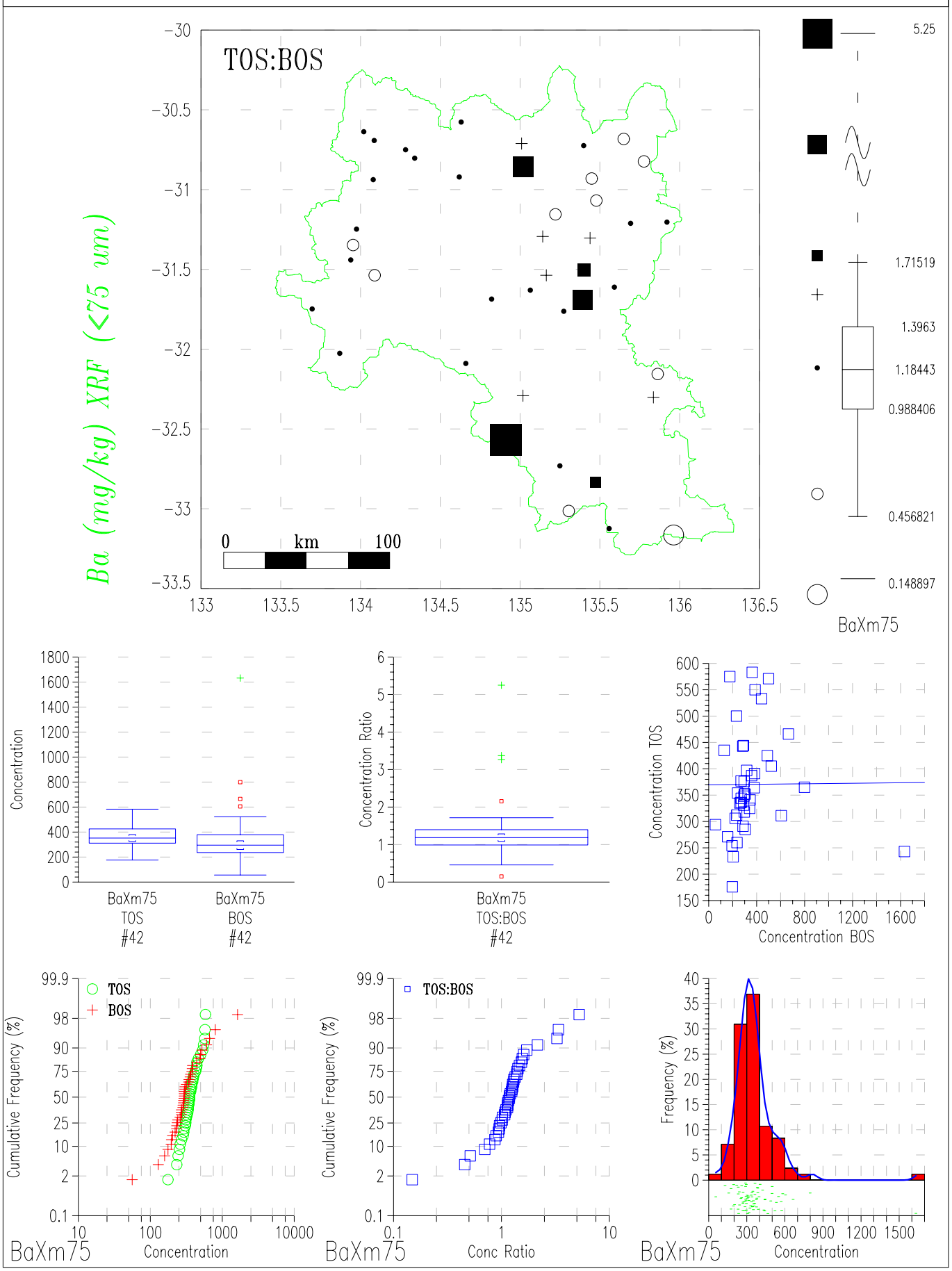
GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



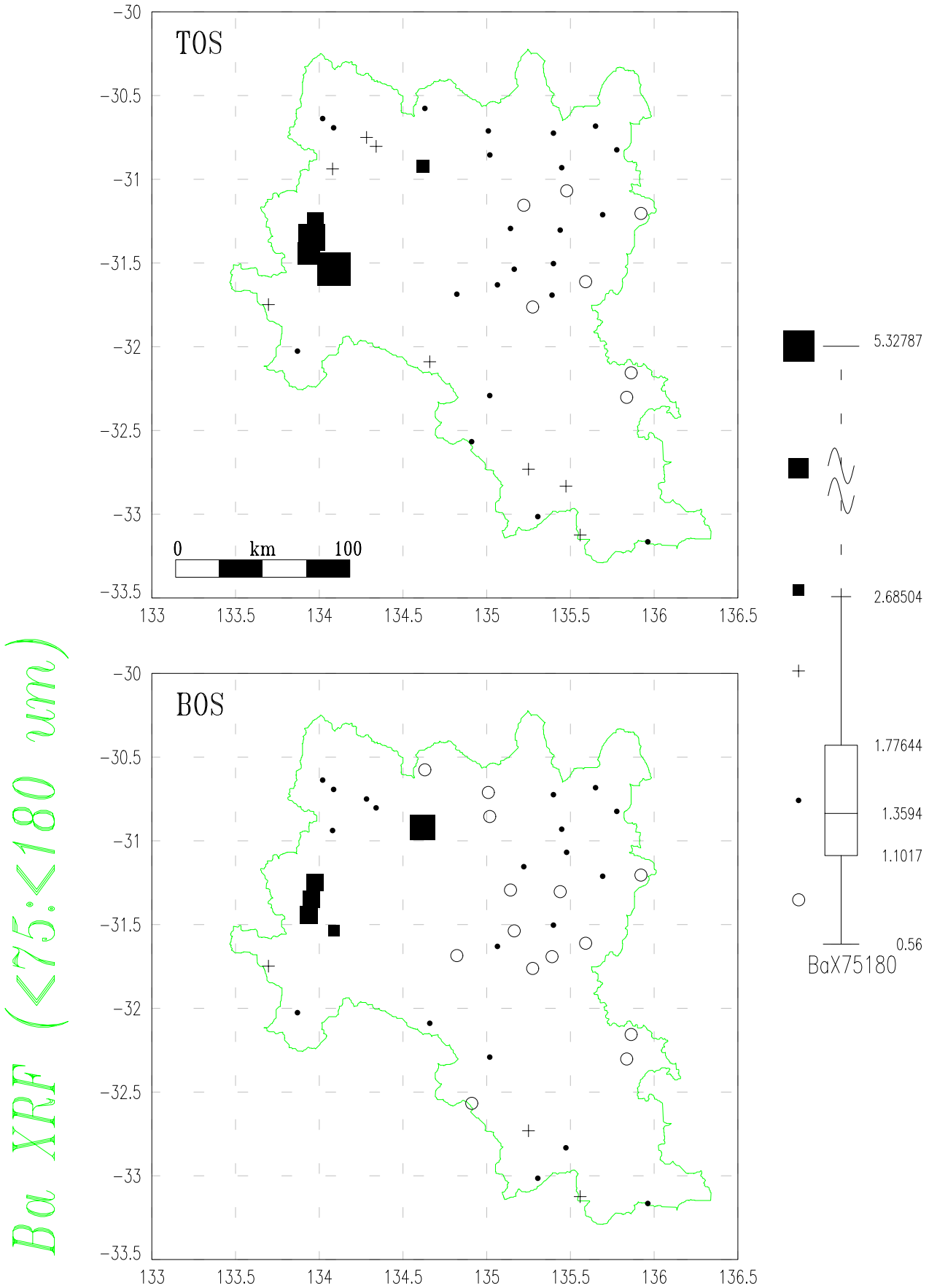
GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



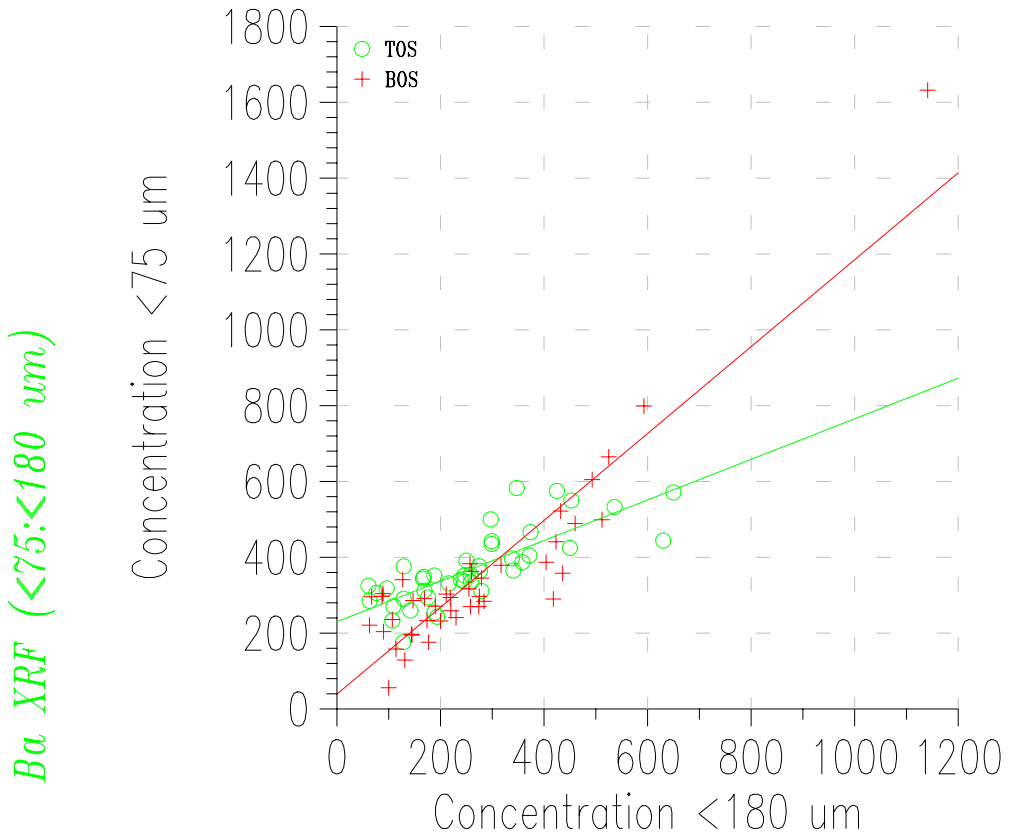
GAWLER GEOCHEMICAL SURVEY

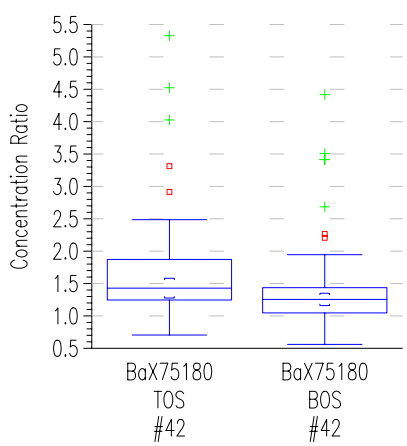
Top & Bottom Outlet Sediments (TOS & BOS)

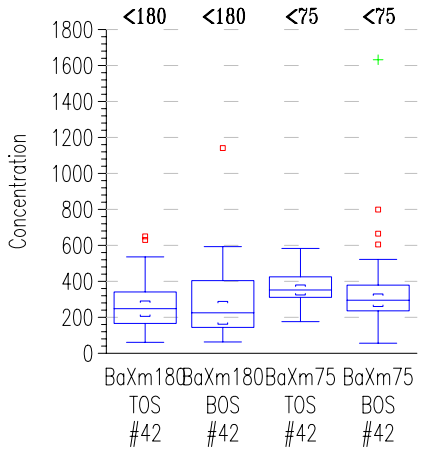


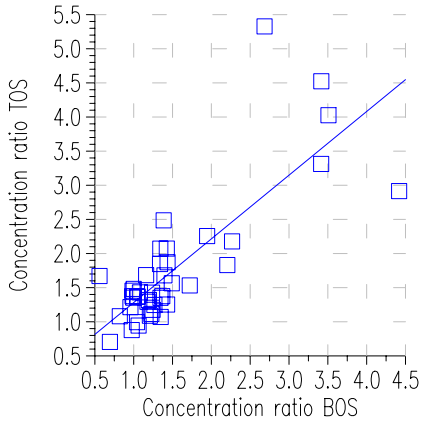
GAWLER GEOCHEMICAL SURVEY

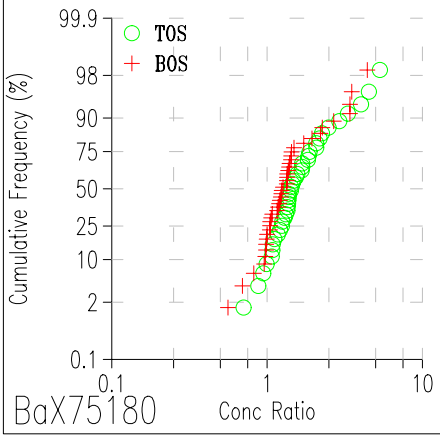
Top & Bottom Outlet Sediments (TOS & BOS)

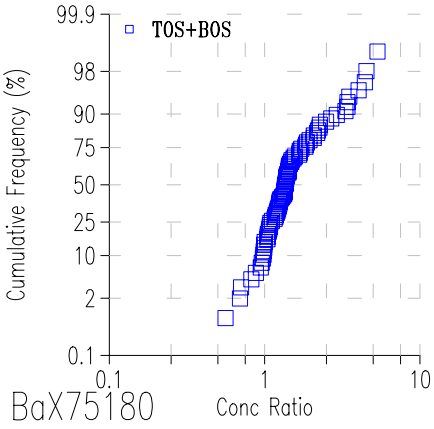


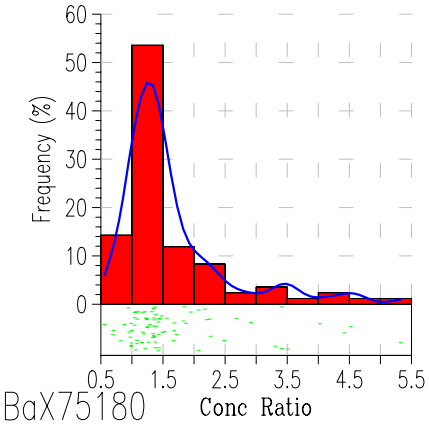








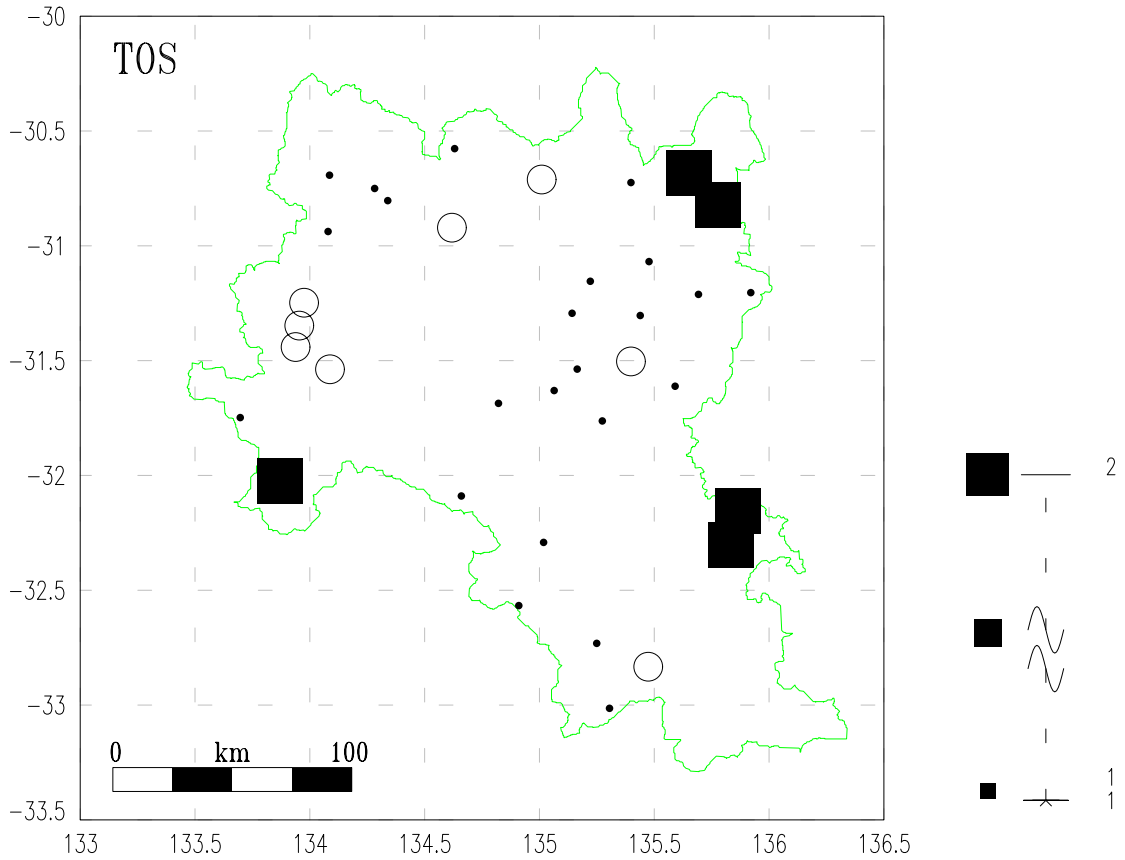


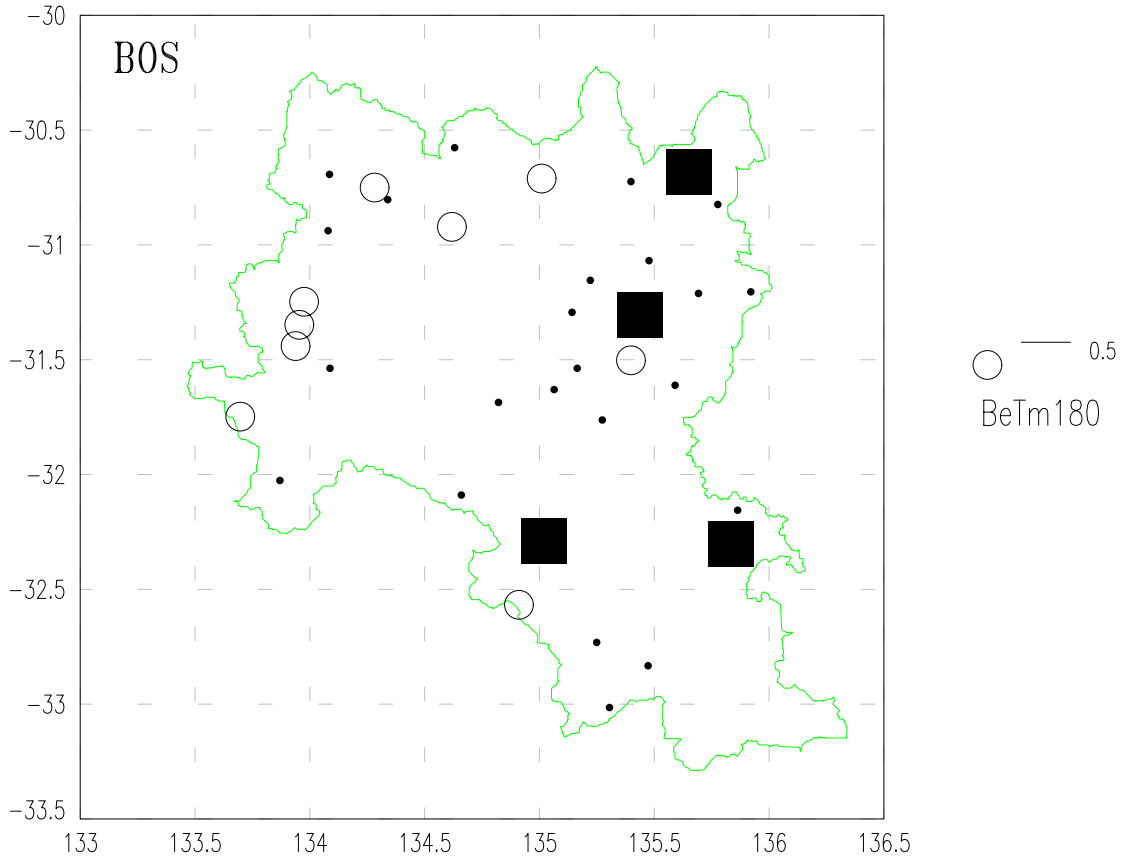


GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)

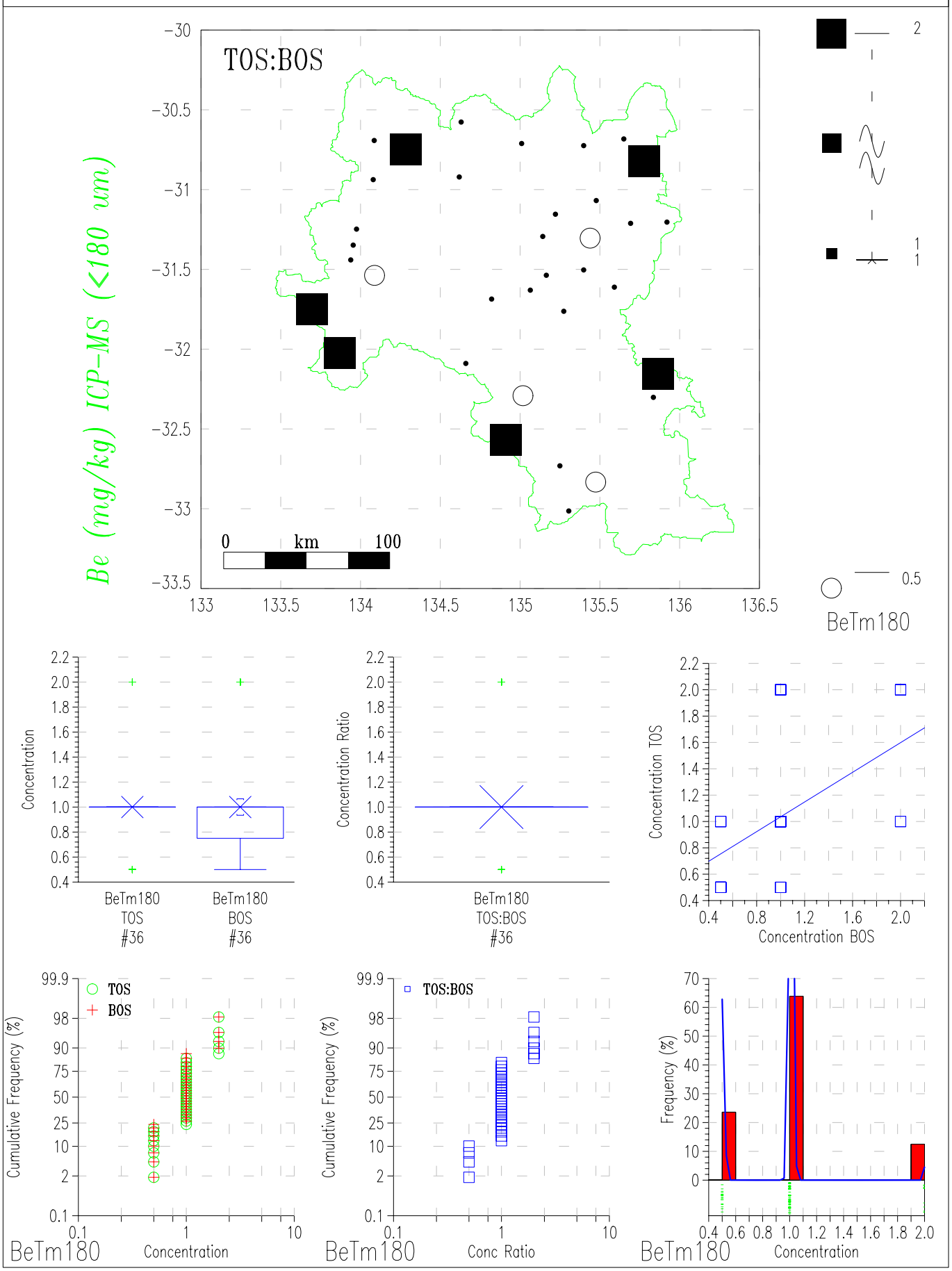
Be (mg/kg) ICP-MS (<180 um)





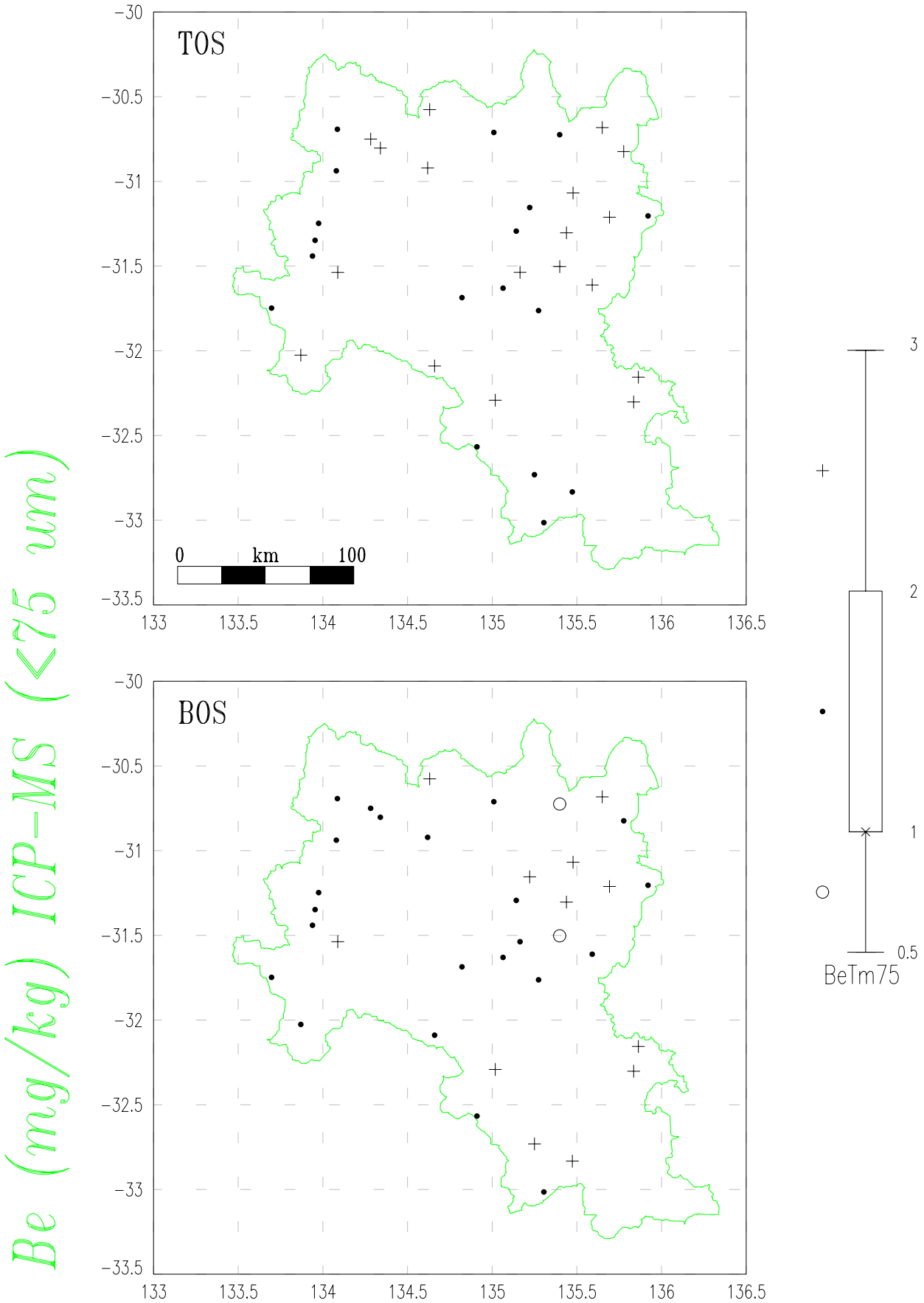
GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



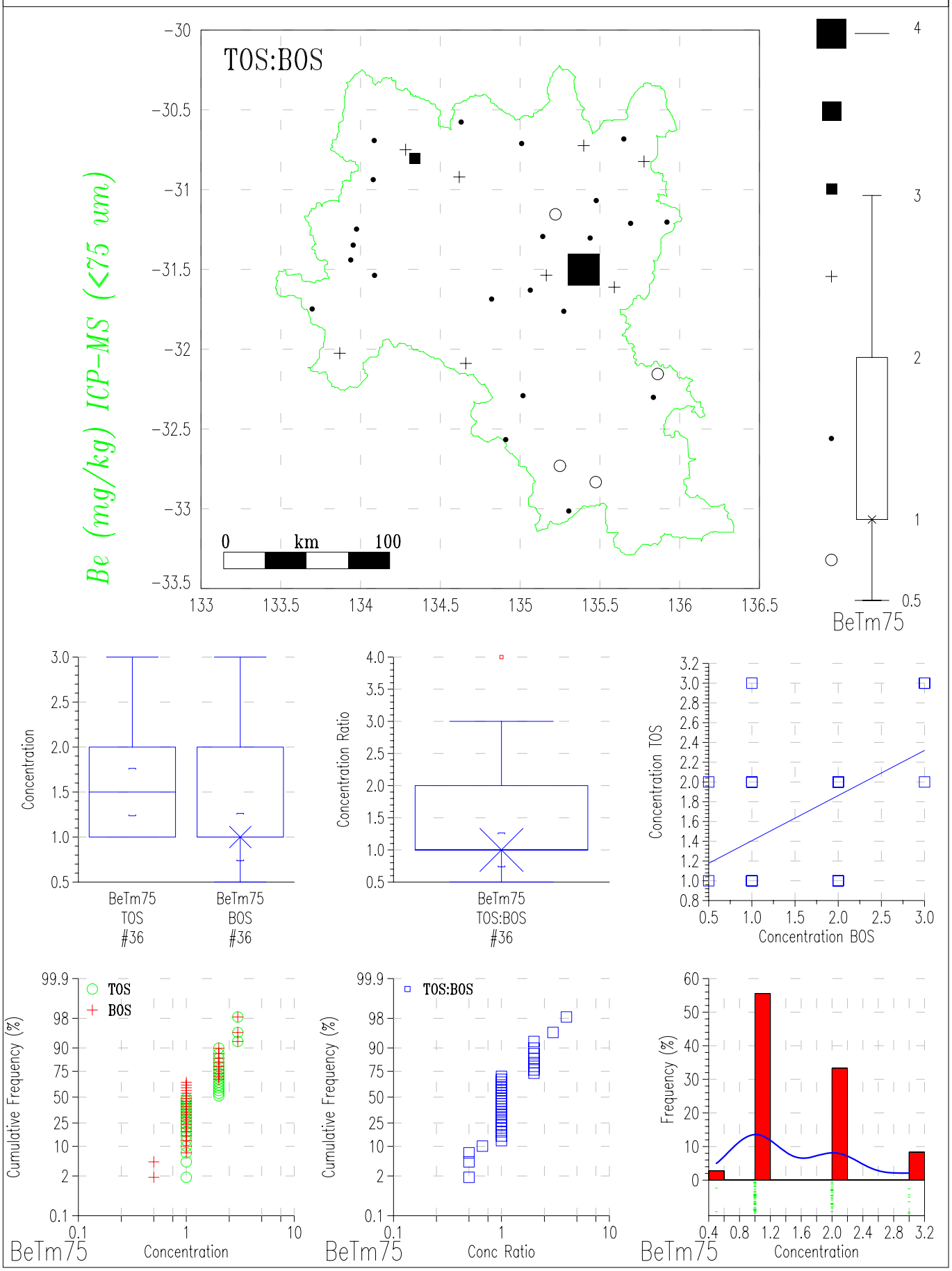
GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



GAWLER GEOCHEMICAL SURVEY

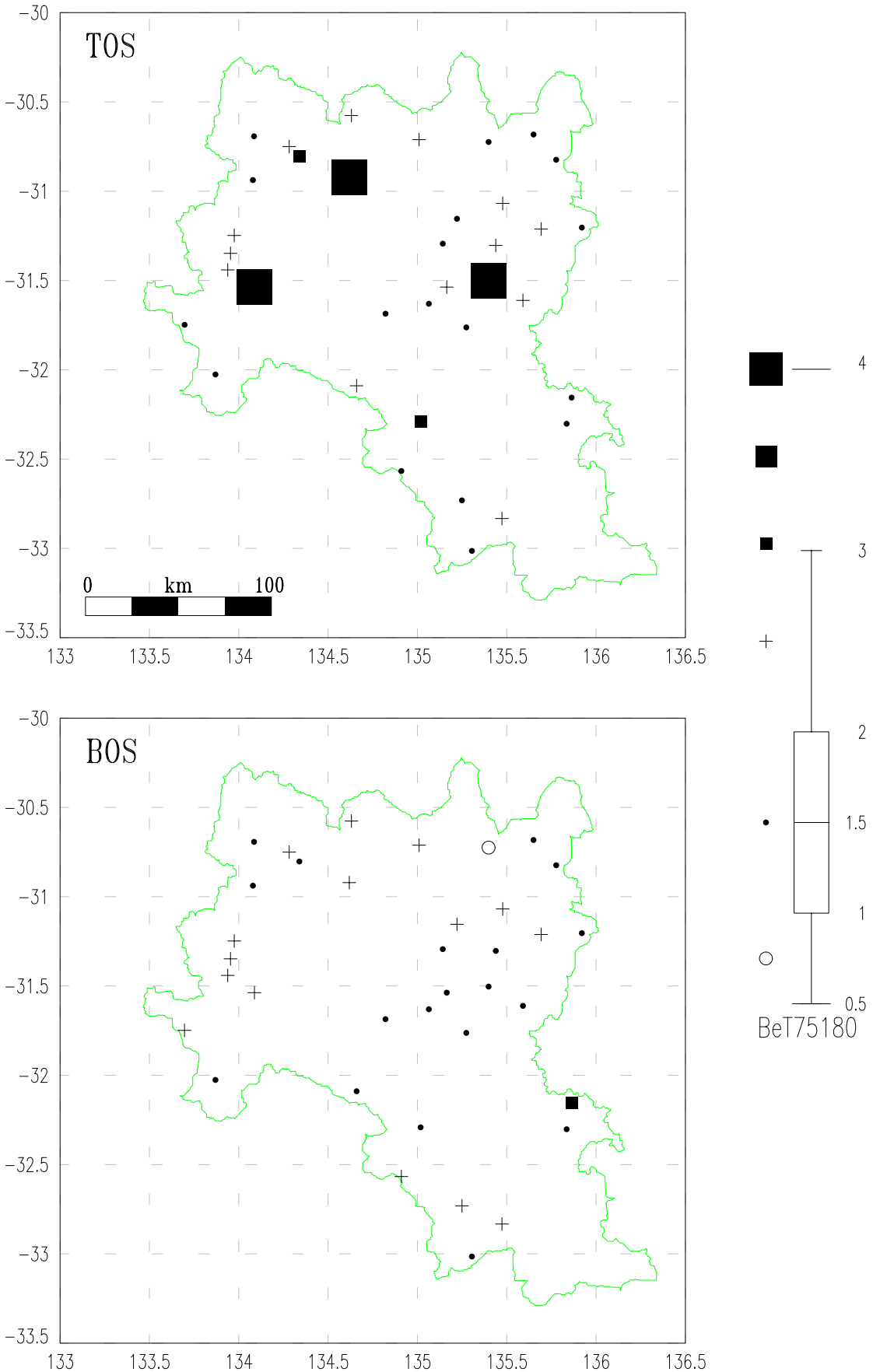
Top & Bottom Outlet Sediments (TOS & BOS)



GAWLER GEOCHEMICAL SURVEY

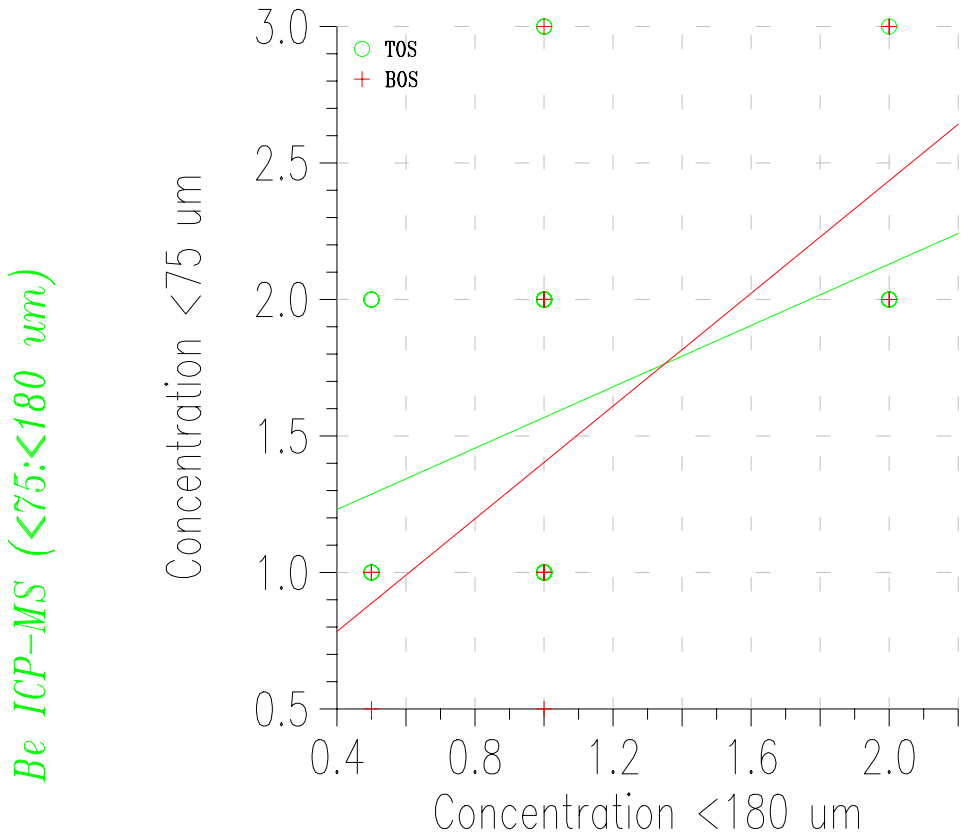
Top & Bottom Outlet Sediments (TOS & BOS)

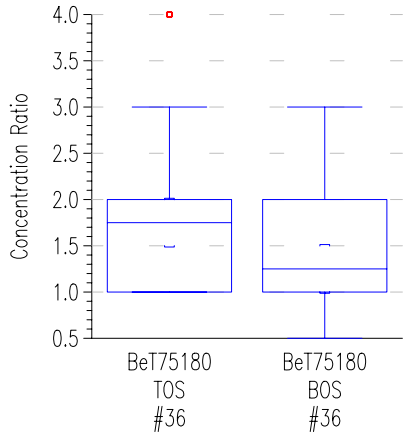
Be ICP-MS (<75:<180 um)

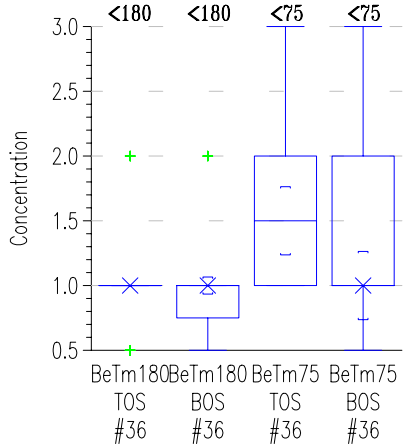


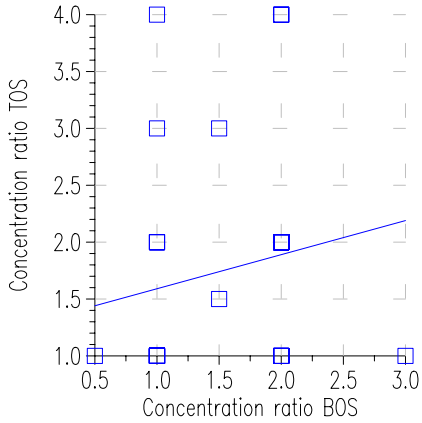
GAWLER GEOCHEMICAL SURVEY

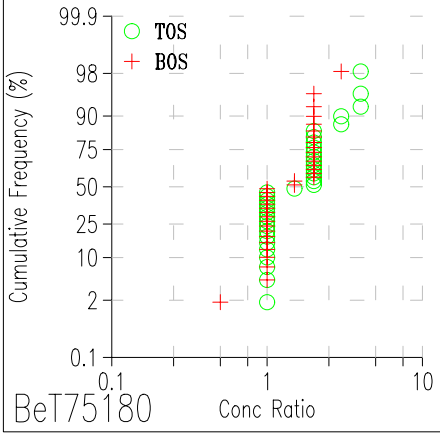
Top & Bottom Outlet Sediments (TOS & BOS)

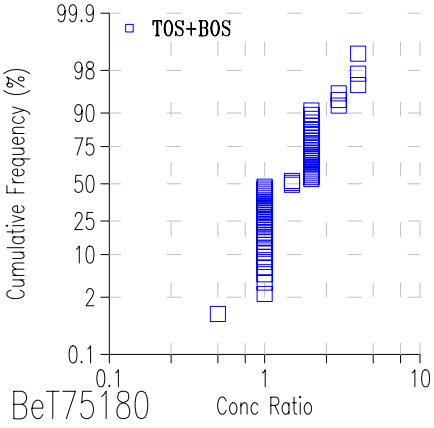


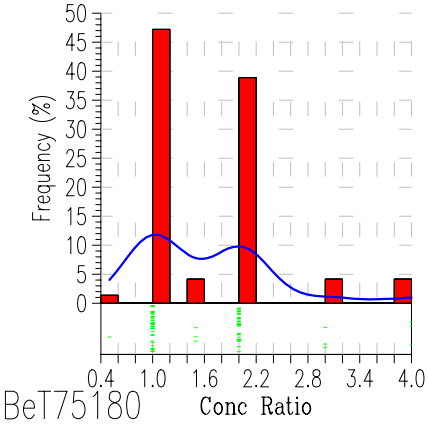






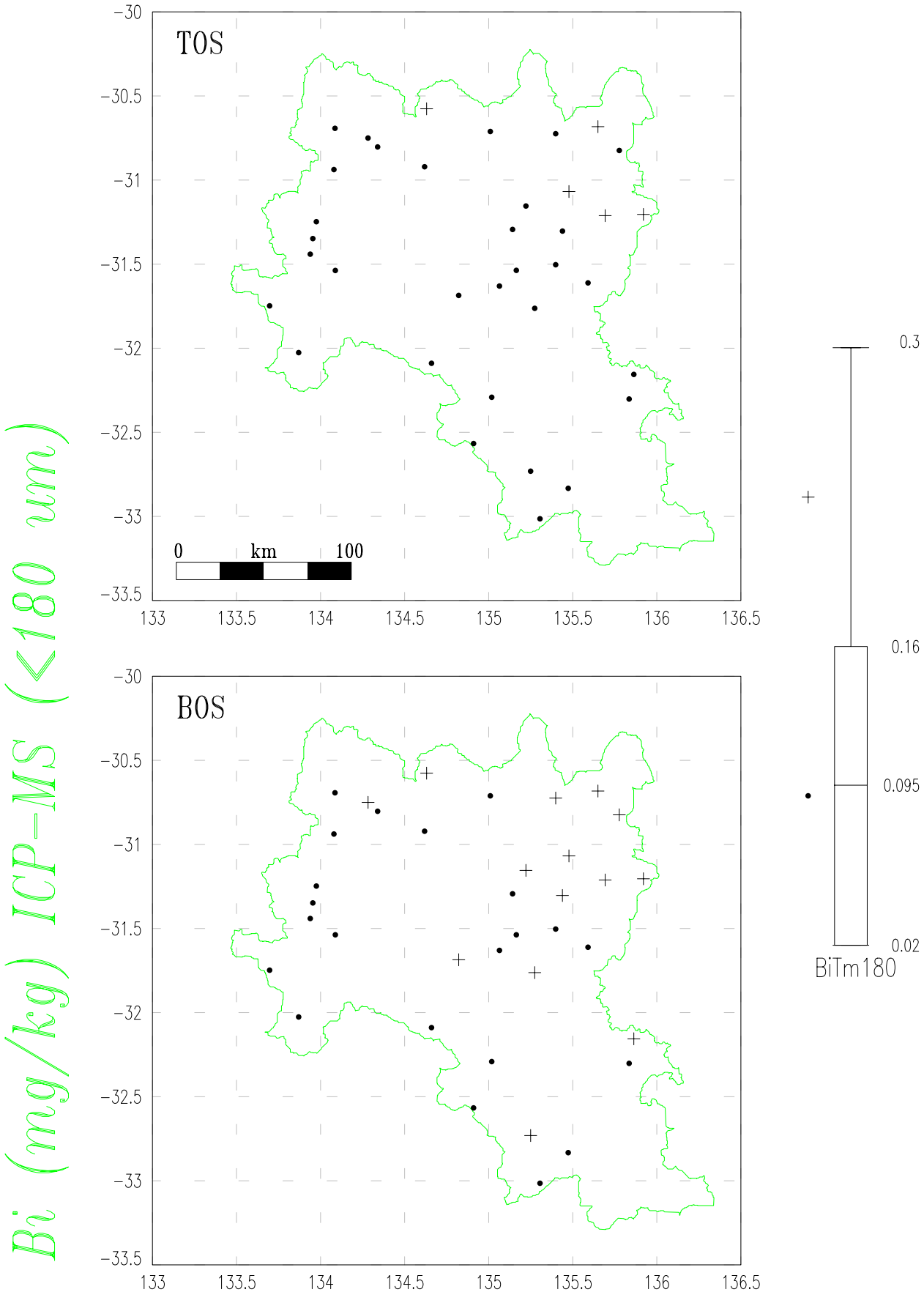






GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



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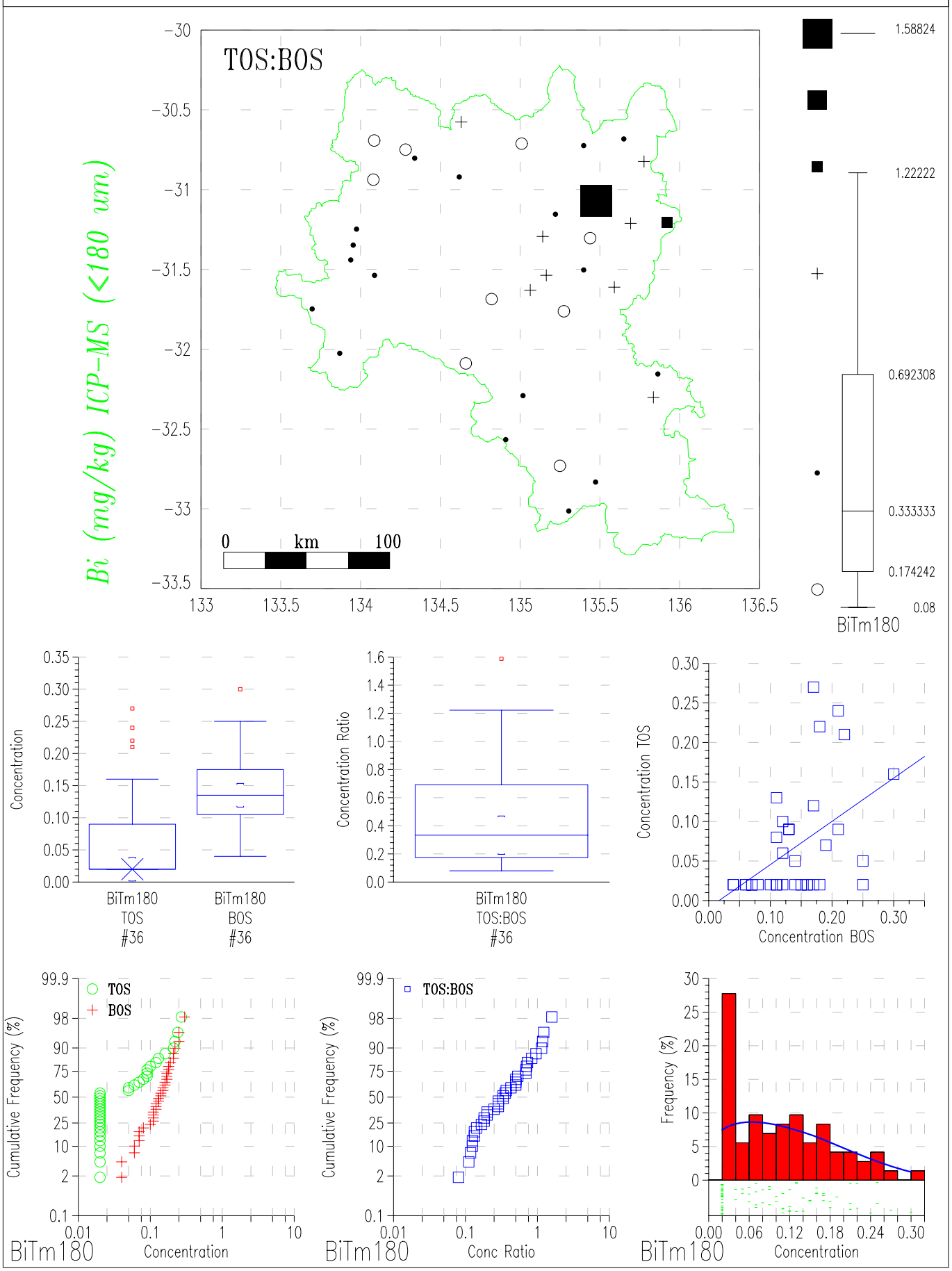
Top & Bottom Outlet Sediments (TOS & BOS)



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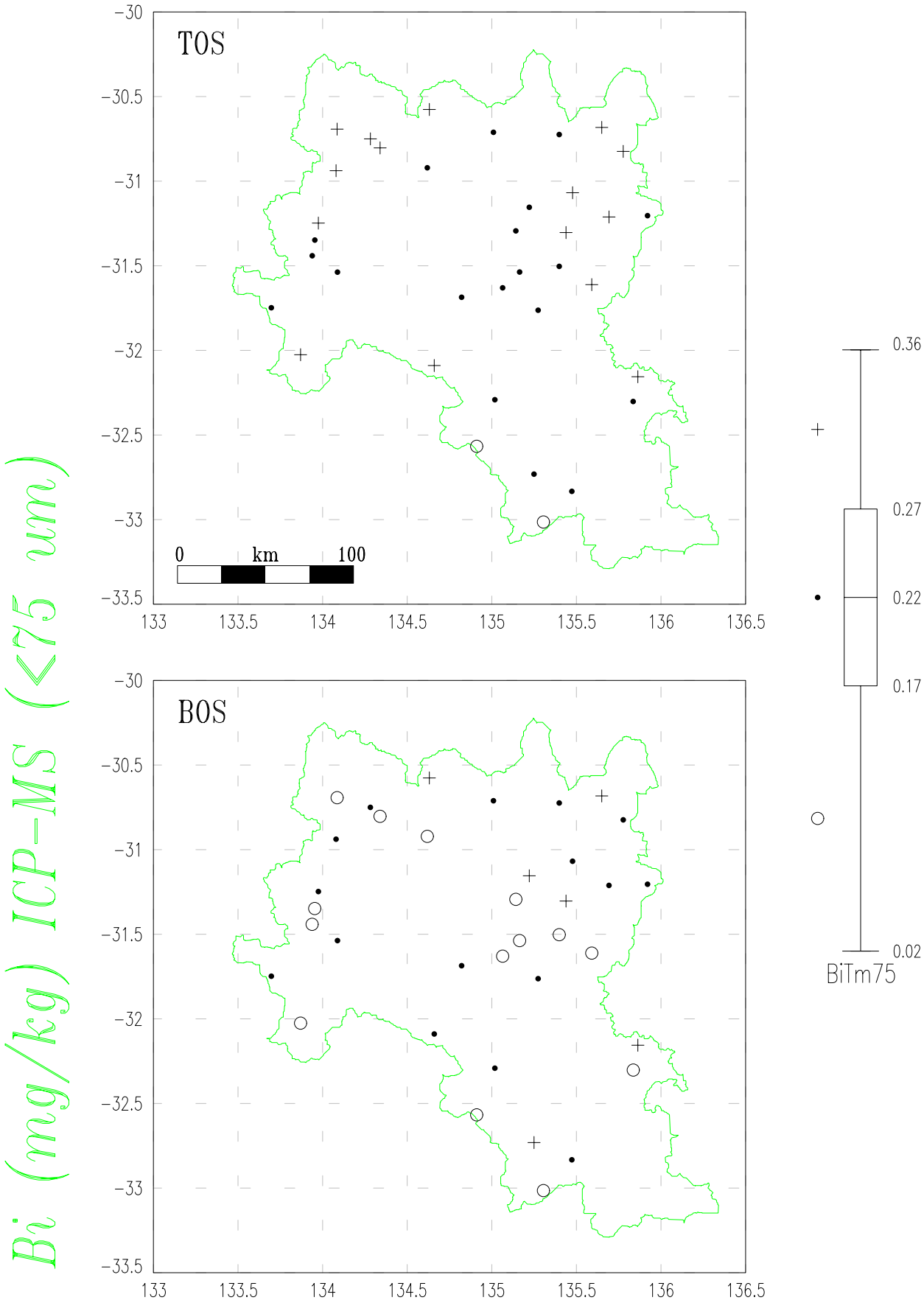

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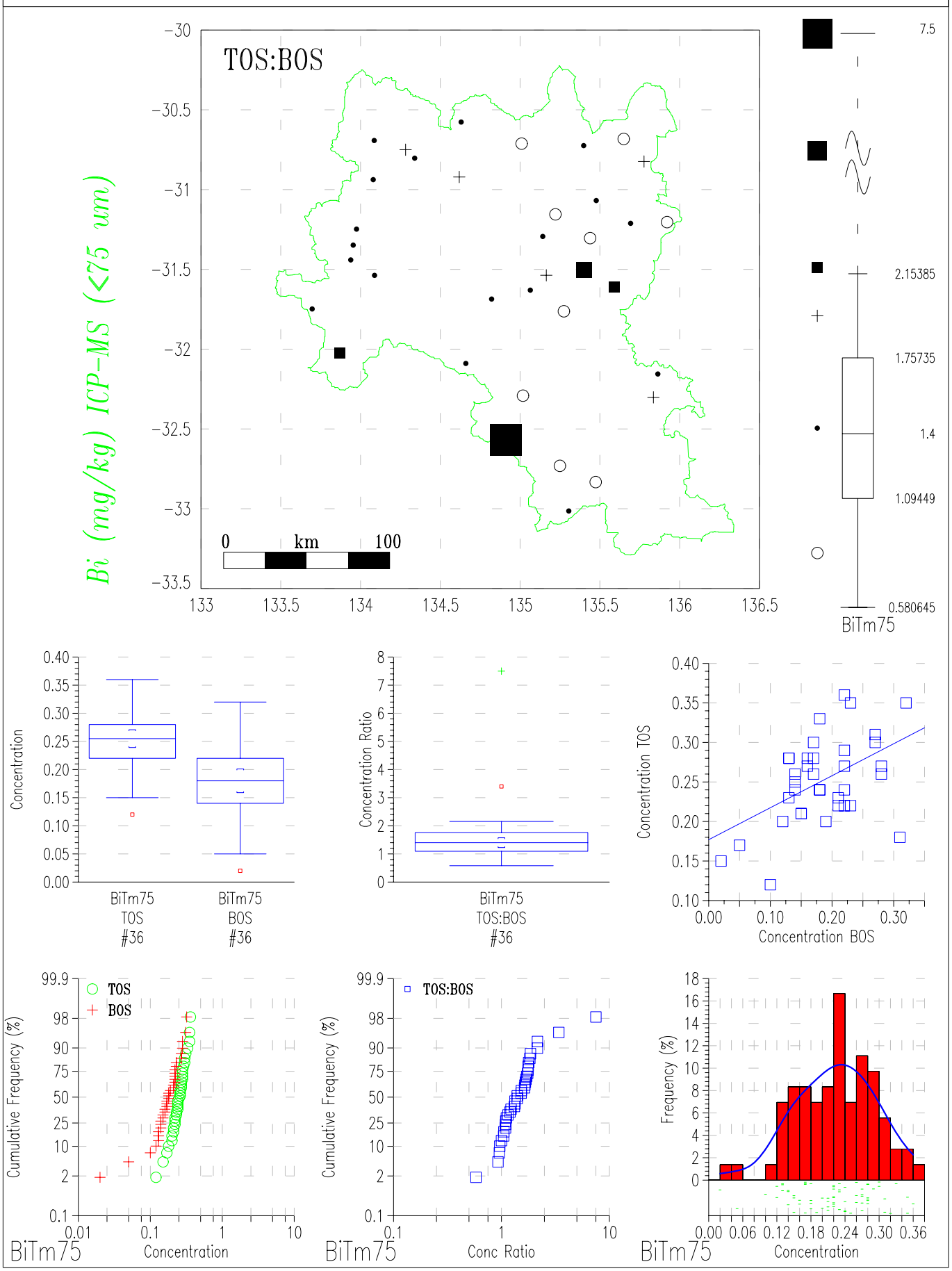
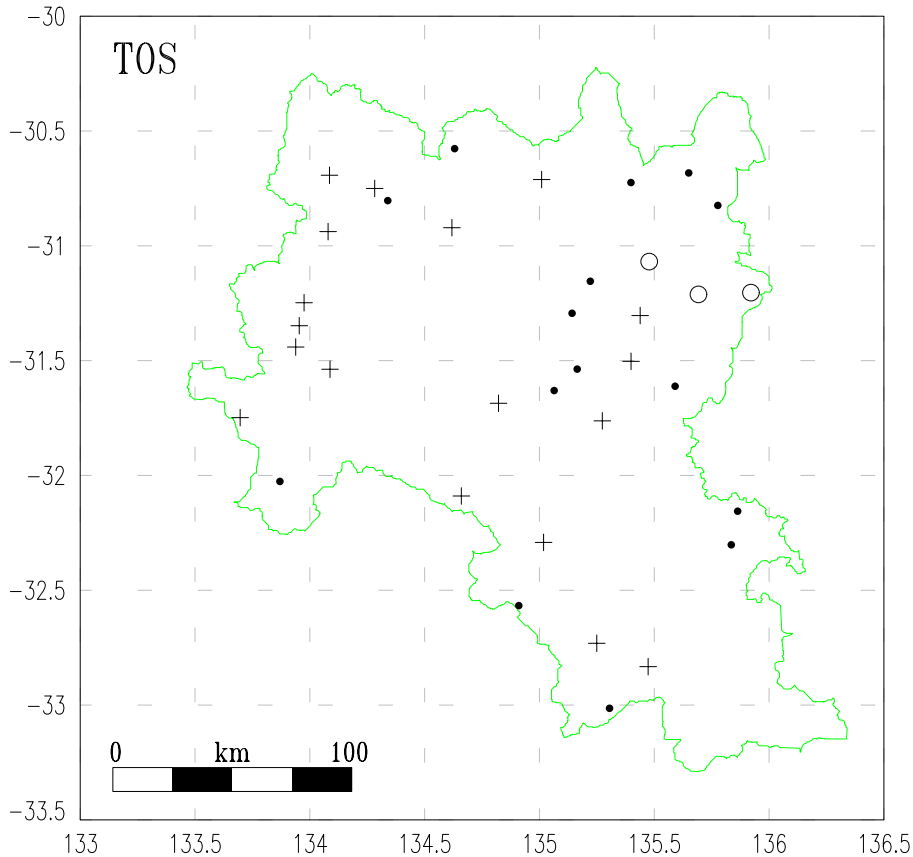
Top & Bottom Outlet Sediments (TOS & BOS)

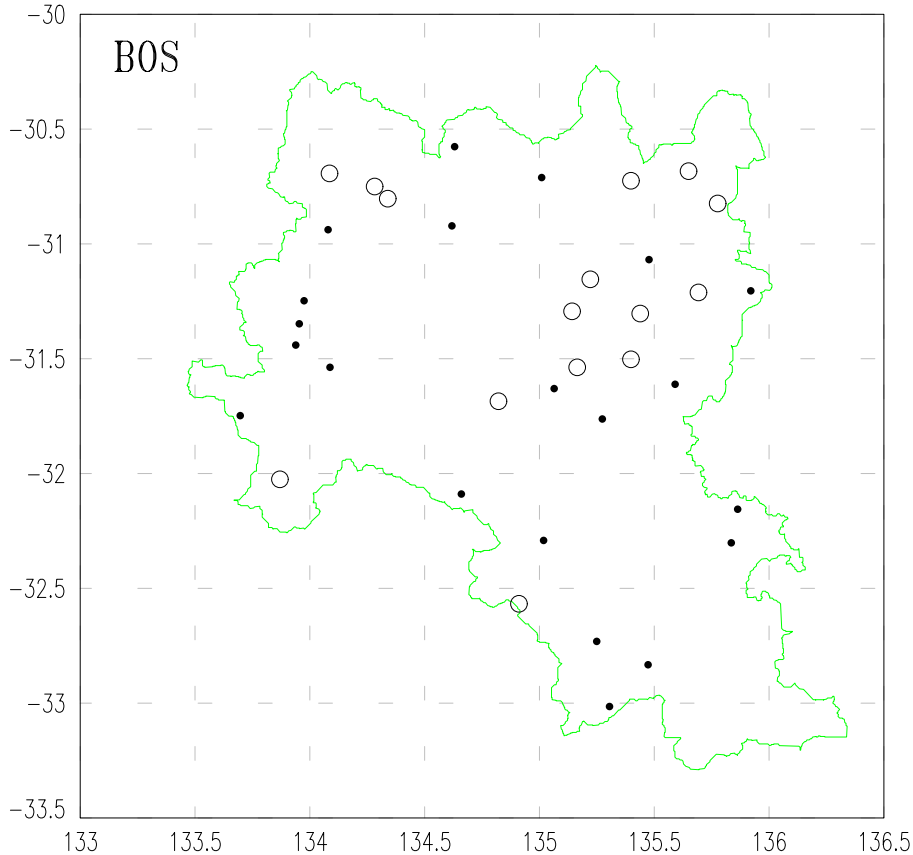


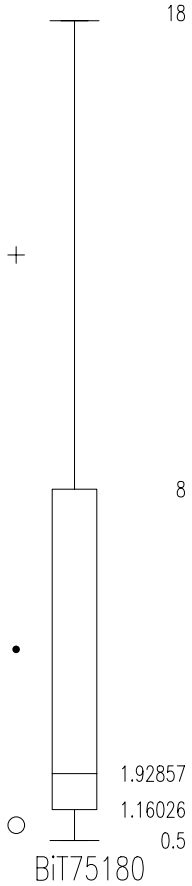
GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)

Bi ICP-MS (<75:<180 um)







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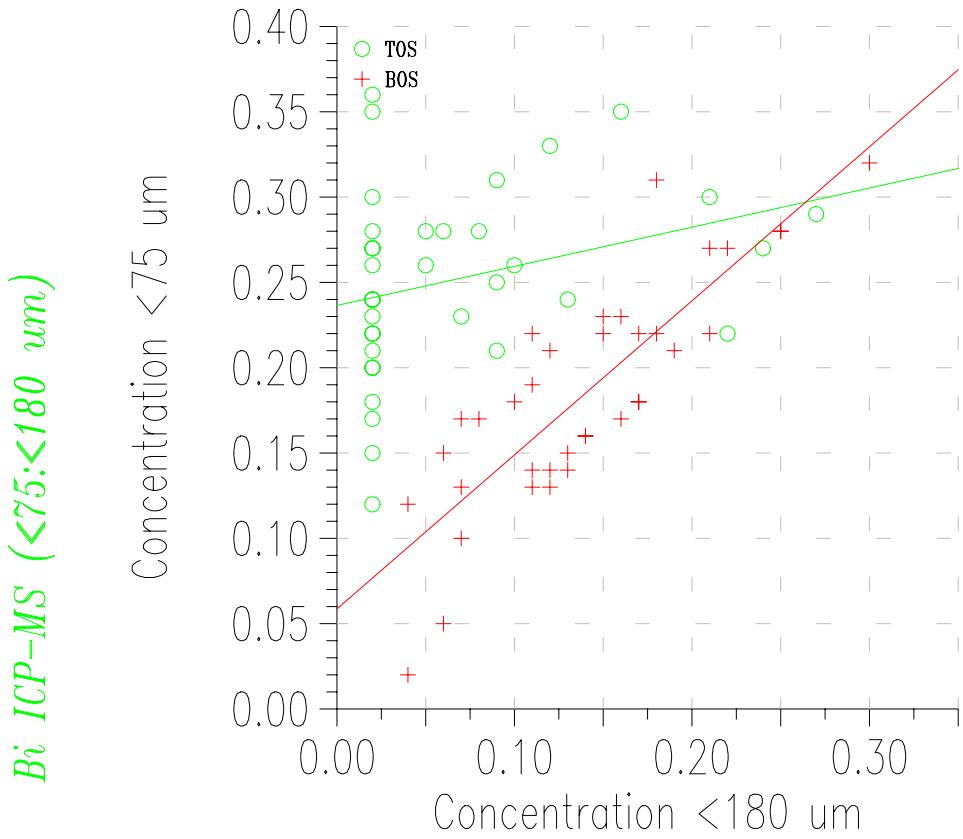
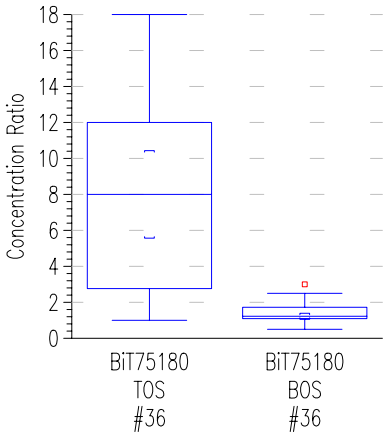
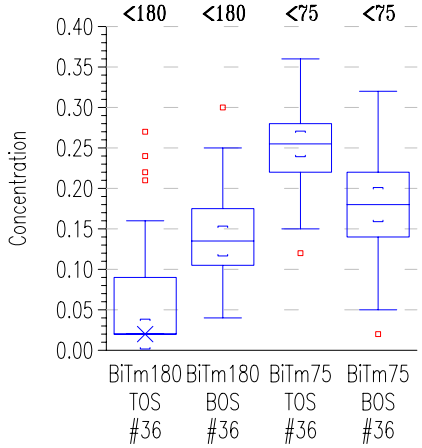
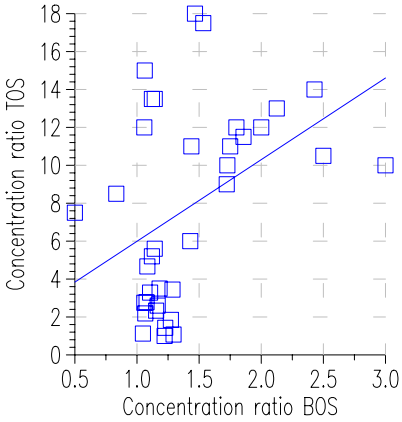
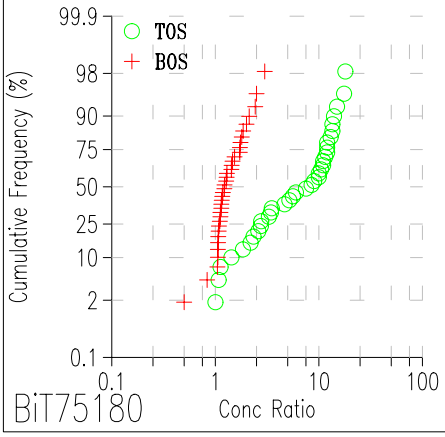
Top & Bottom Outlet Sediments (TOS & BOS)

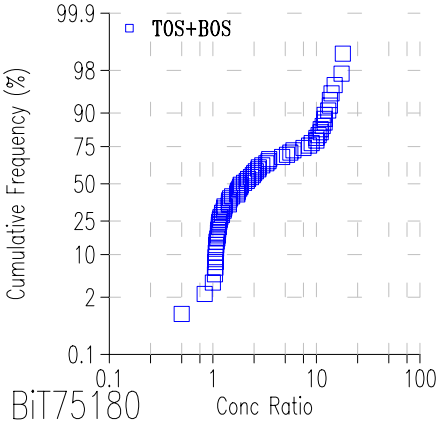


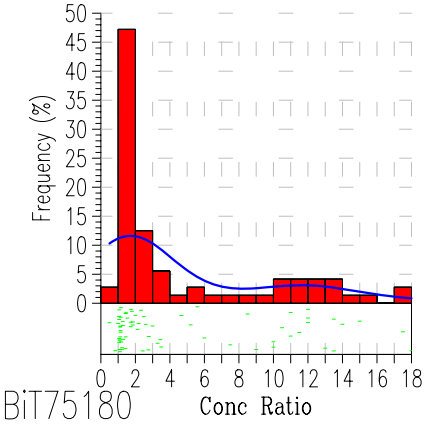






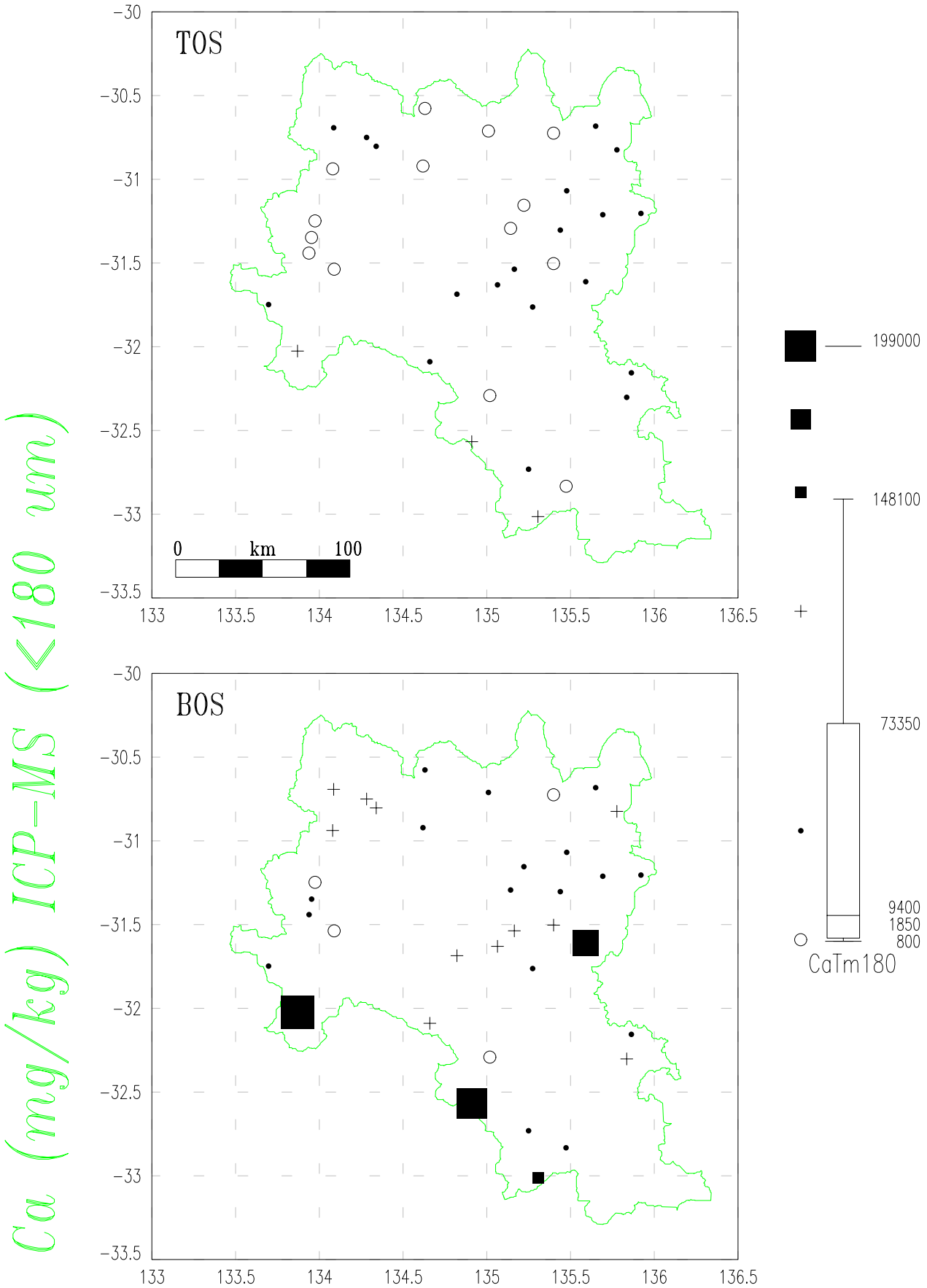






GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



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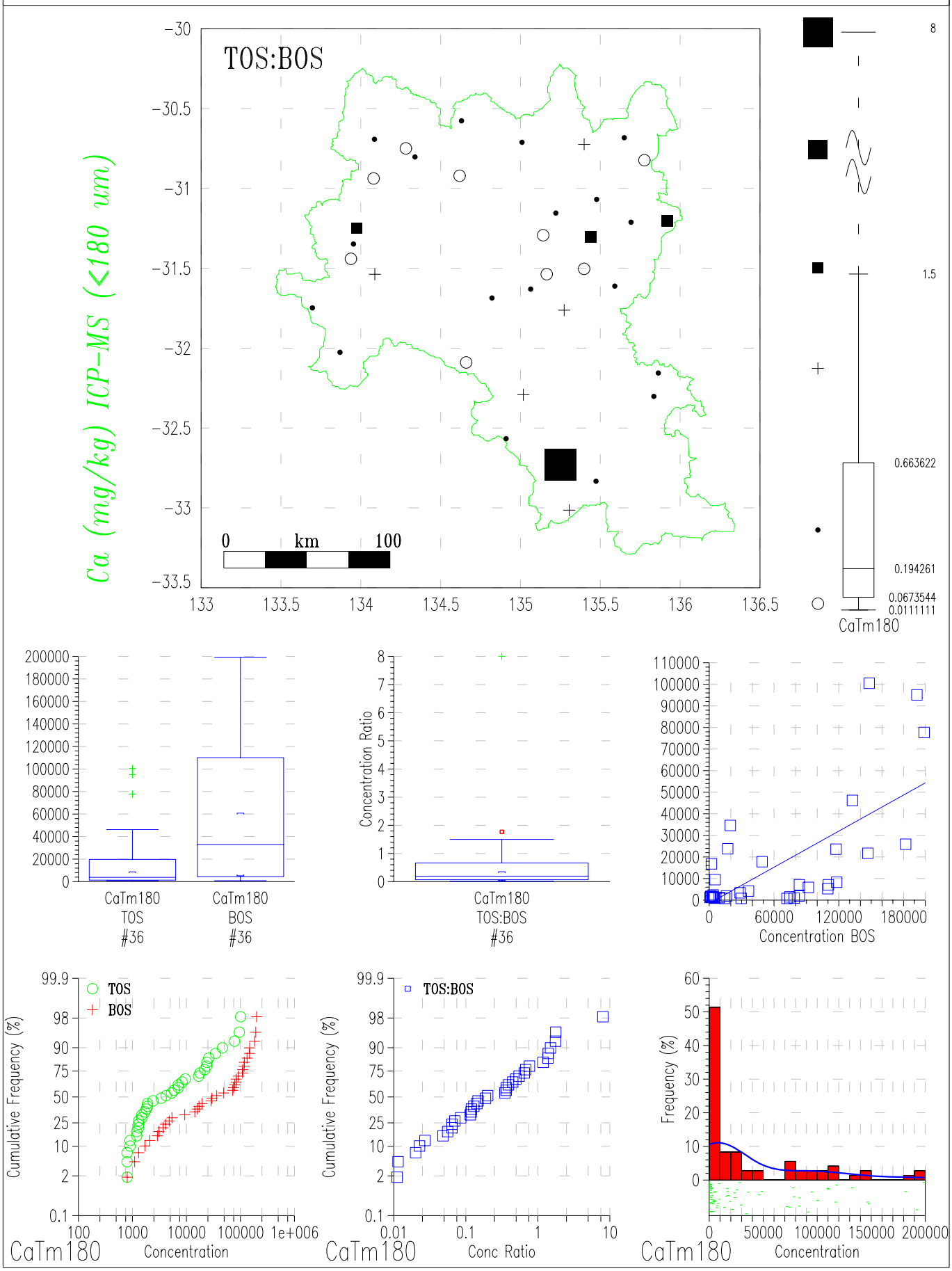
Top & Bottom Outlet Sediments (TOS & BOS)



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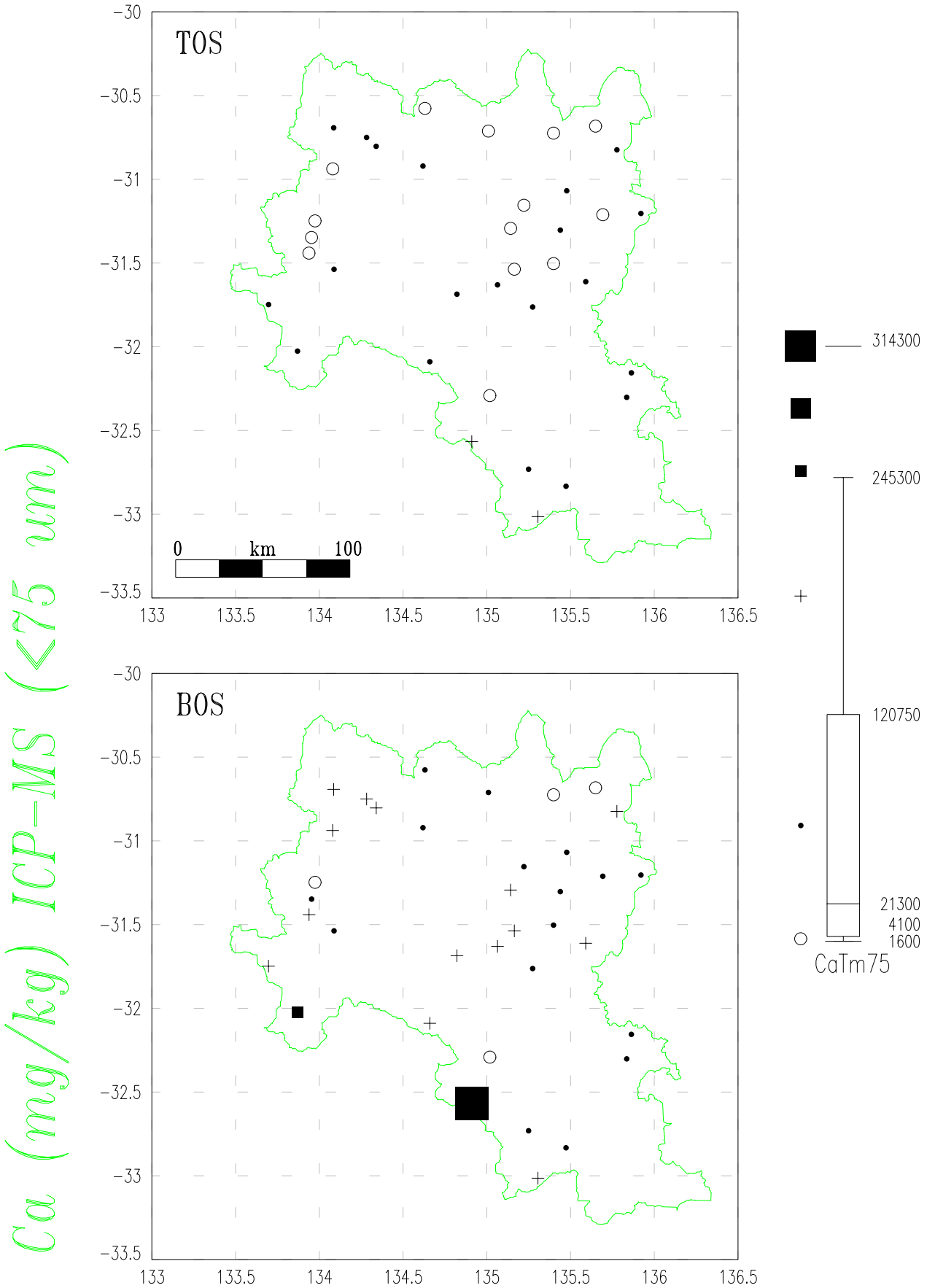
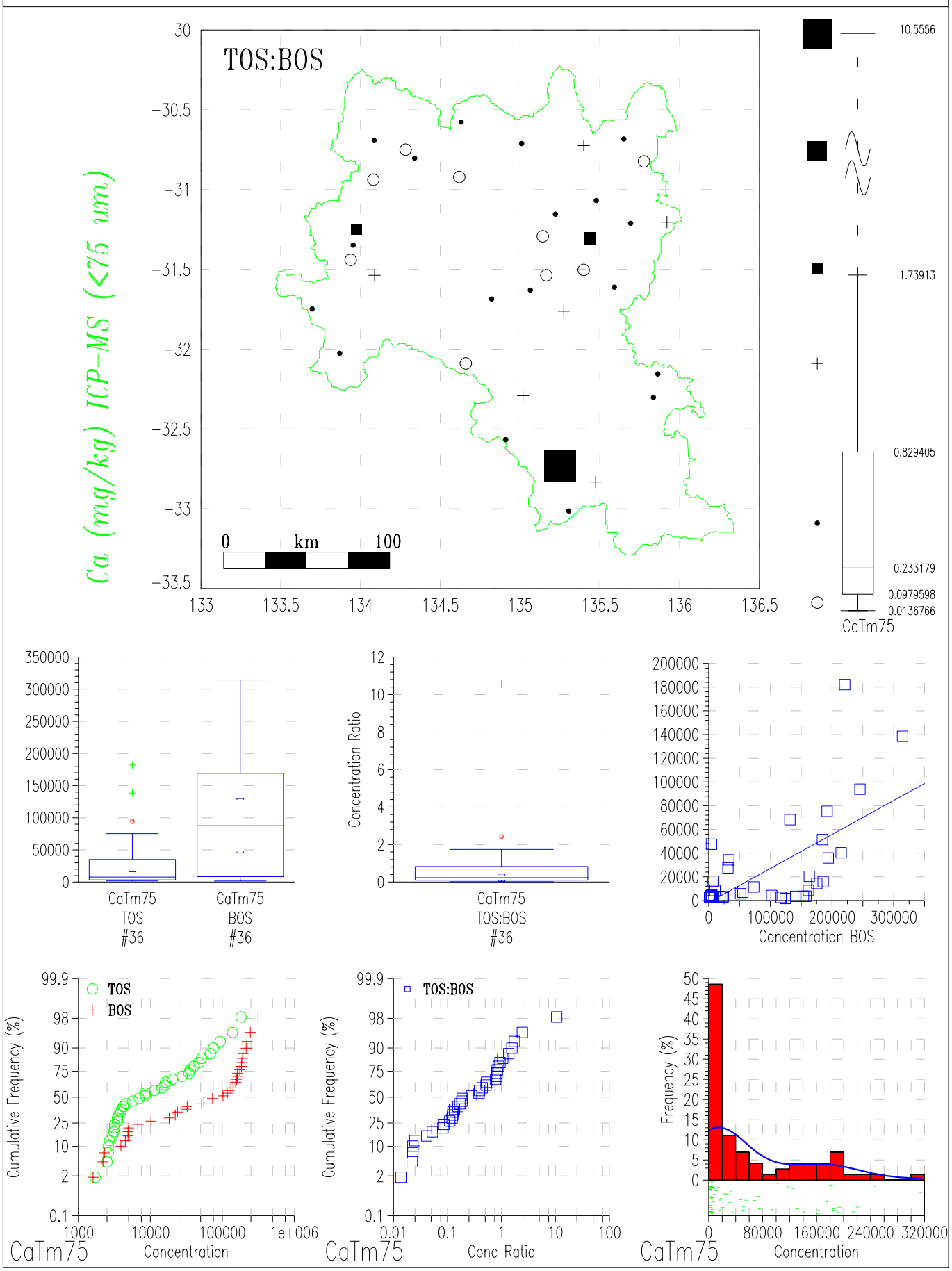


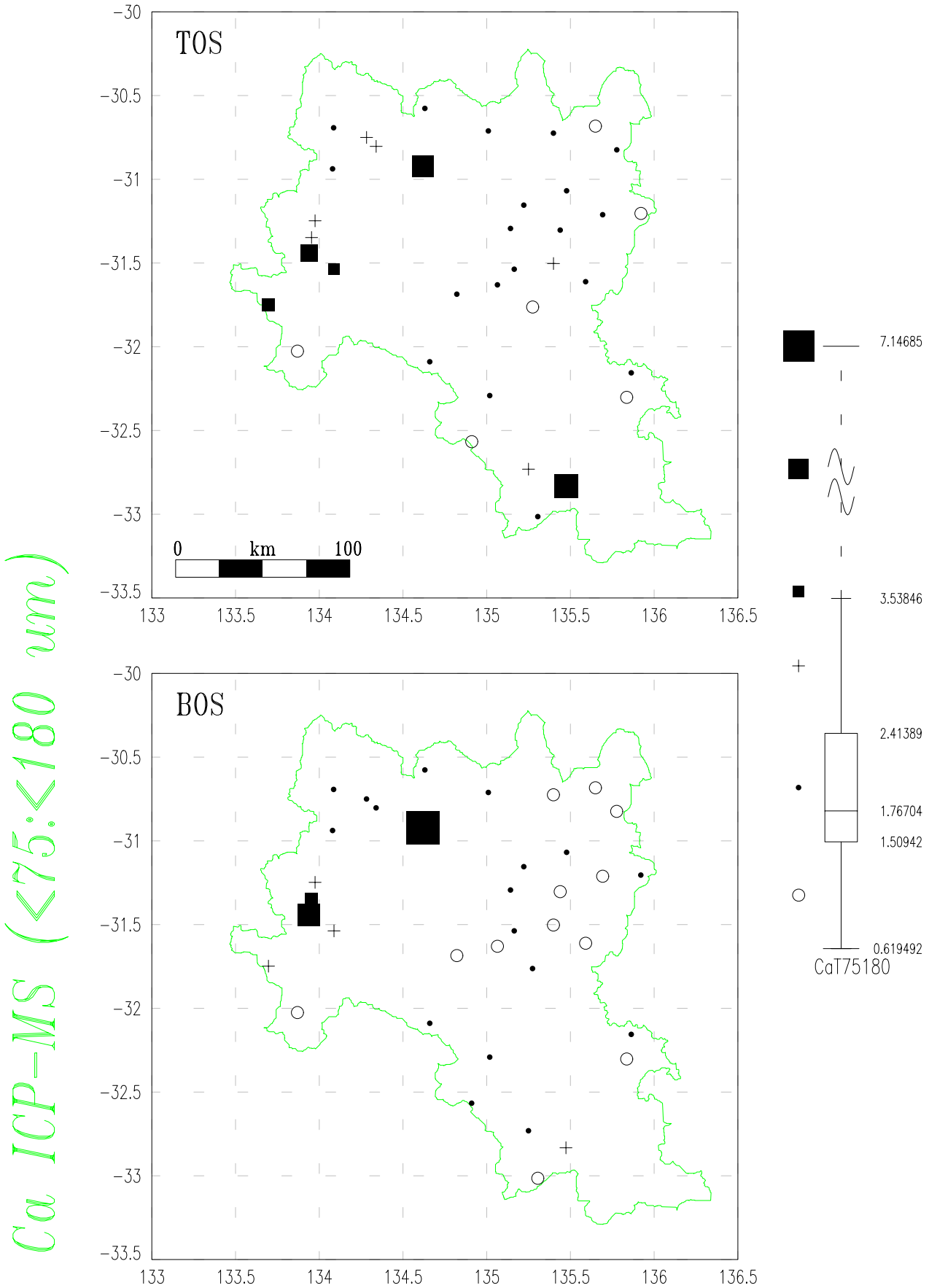
GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



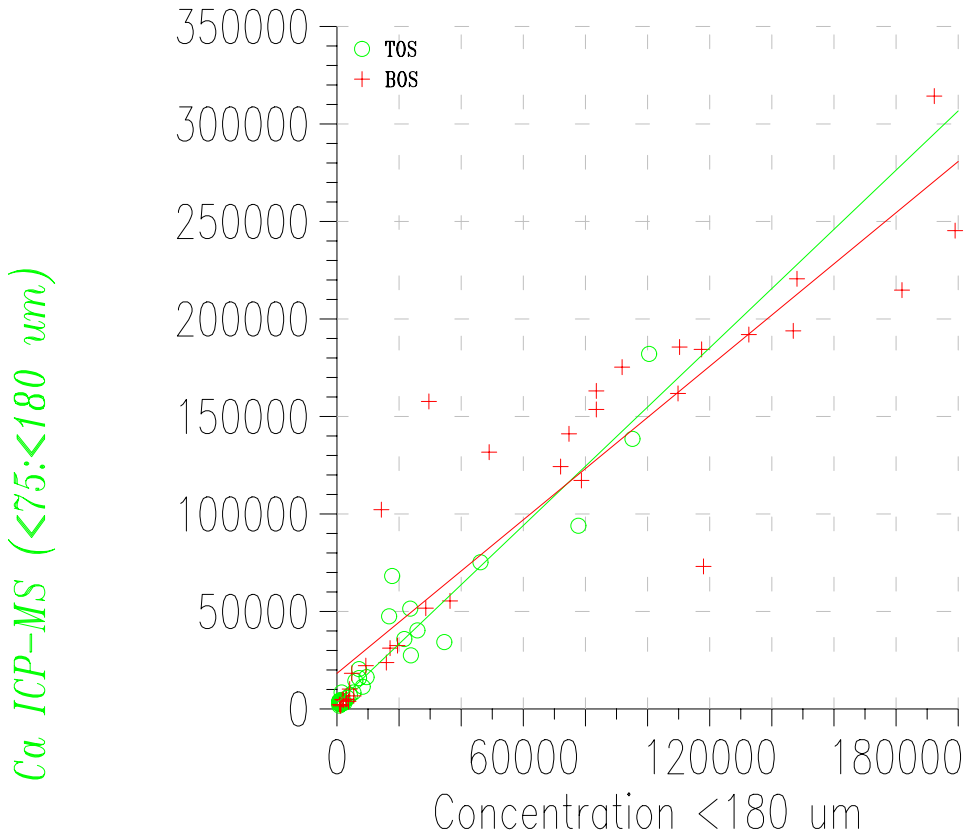
GAWLER GEOCHEMICAL SURVEY

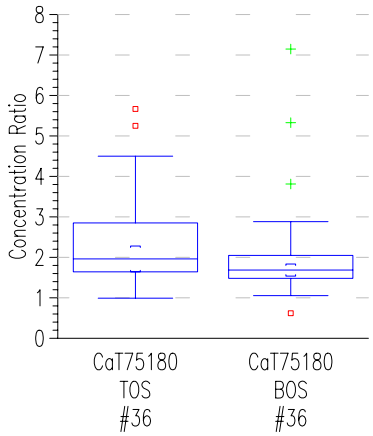
Top & Bottom Outlet Sediments (TOS & BOS)

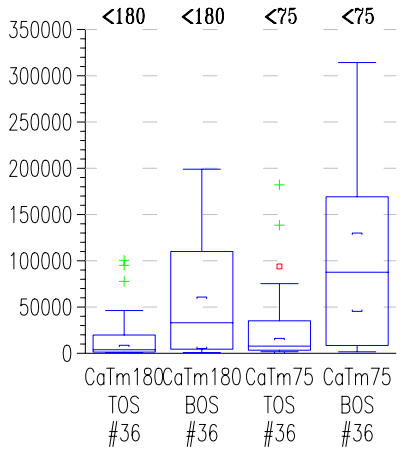


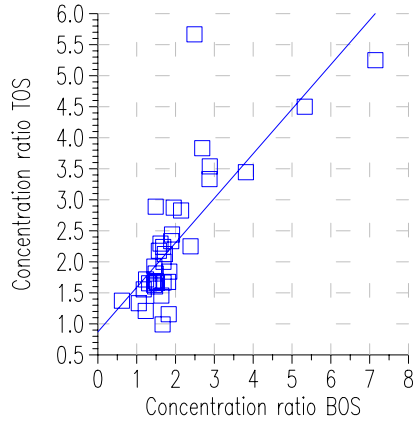
GAWLER GEOCHEMICAL SURVEY

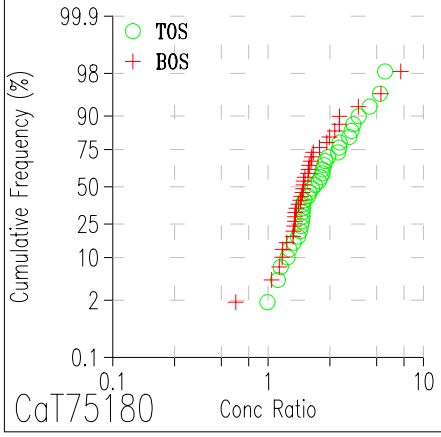
Top & Bottom Outlet Sediments (TOS & BOS)

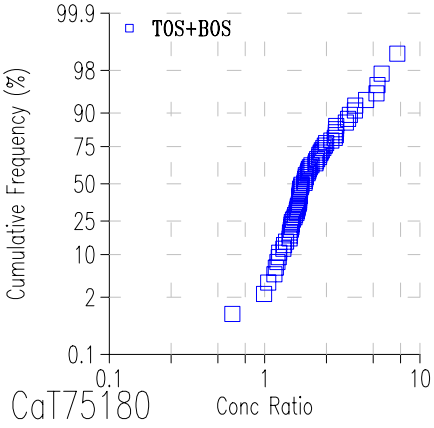


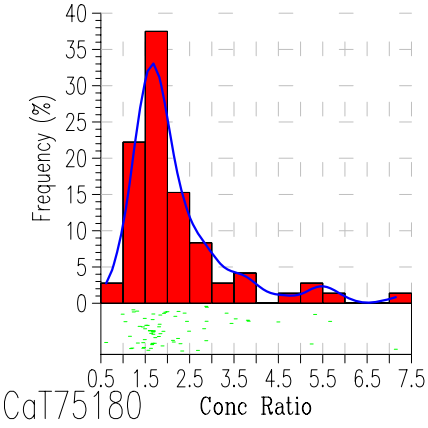






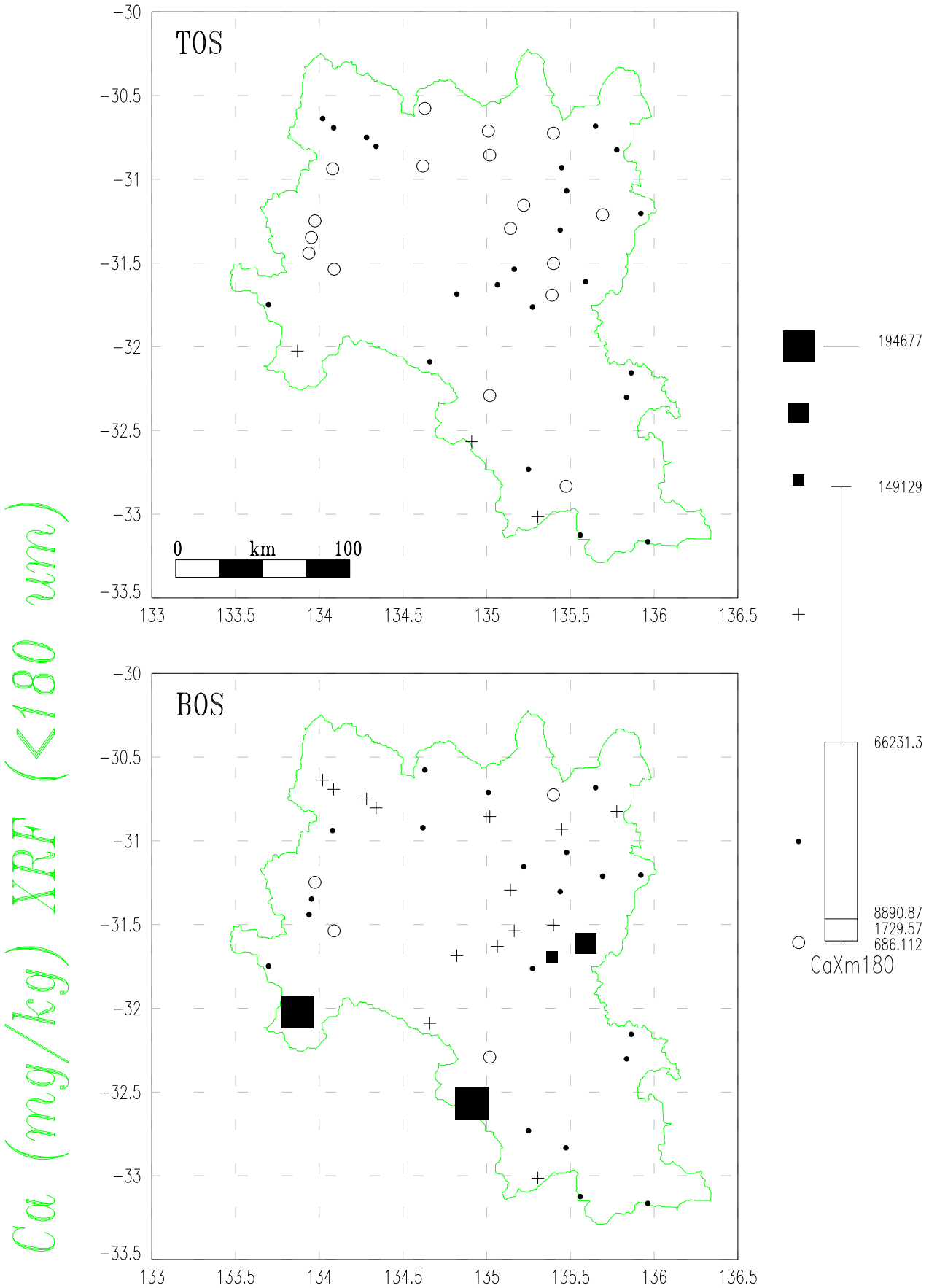






GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



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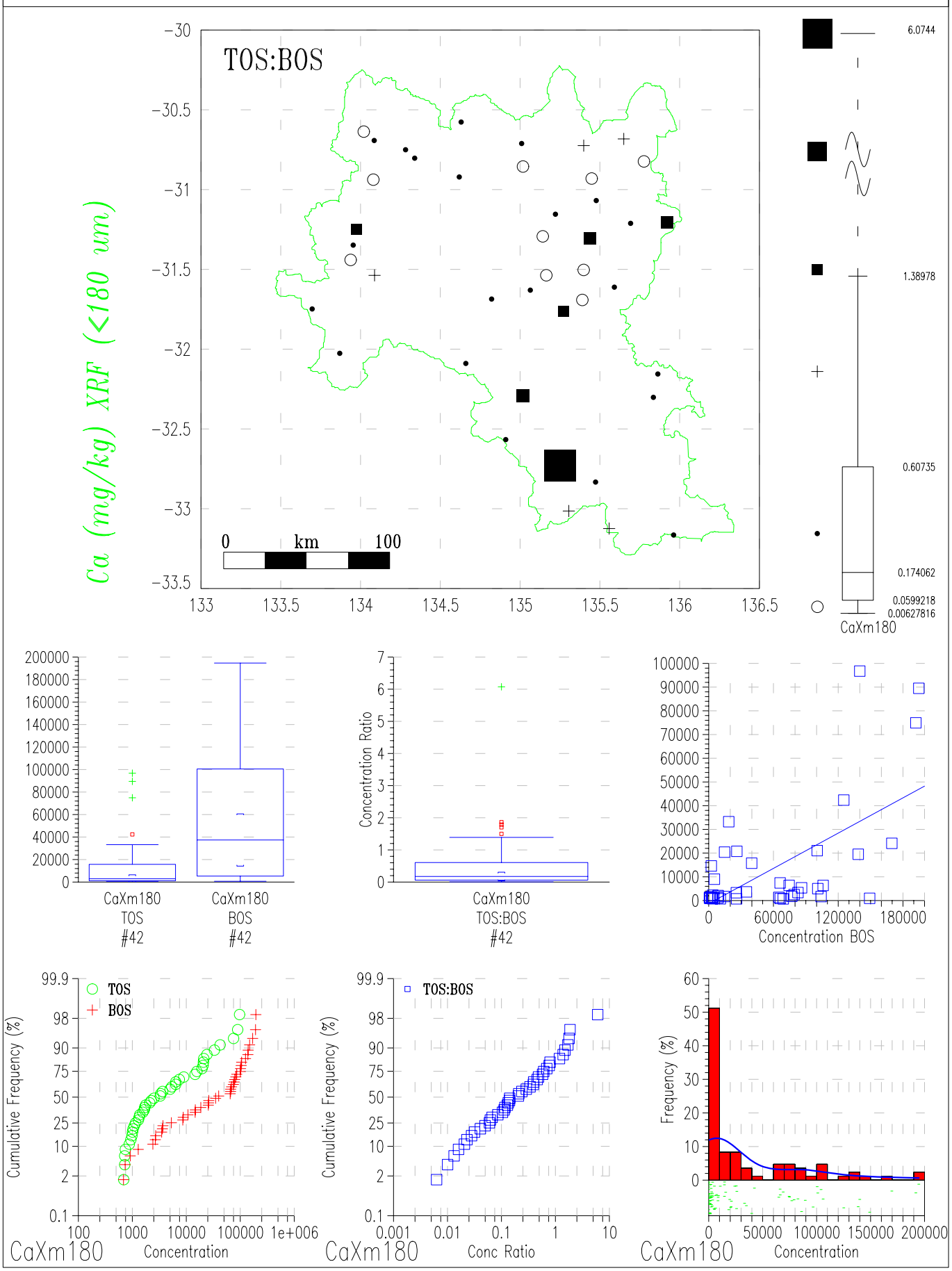

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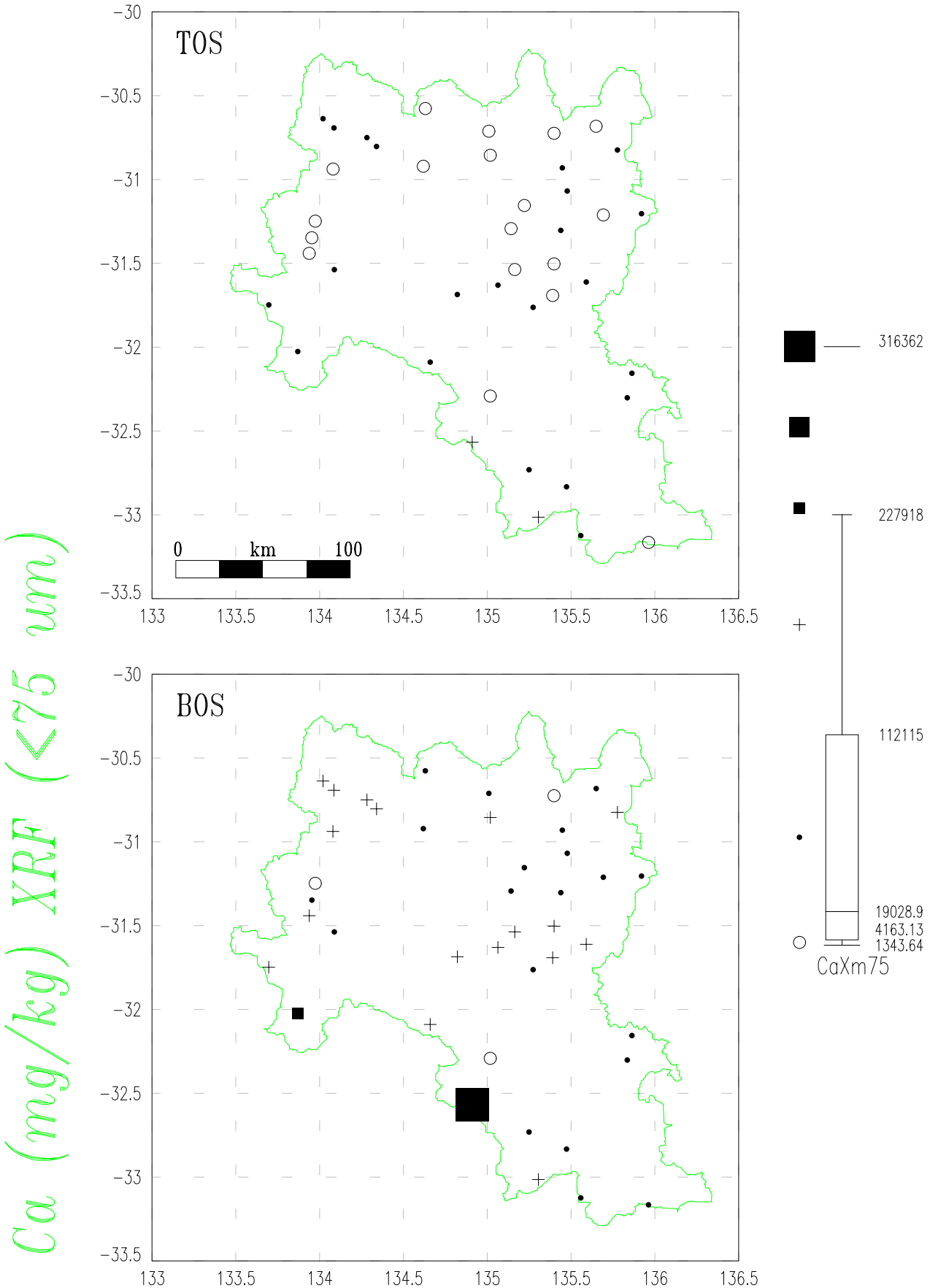

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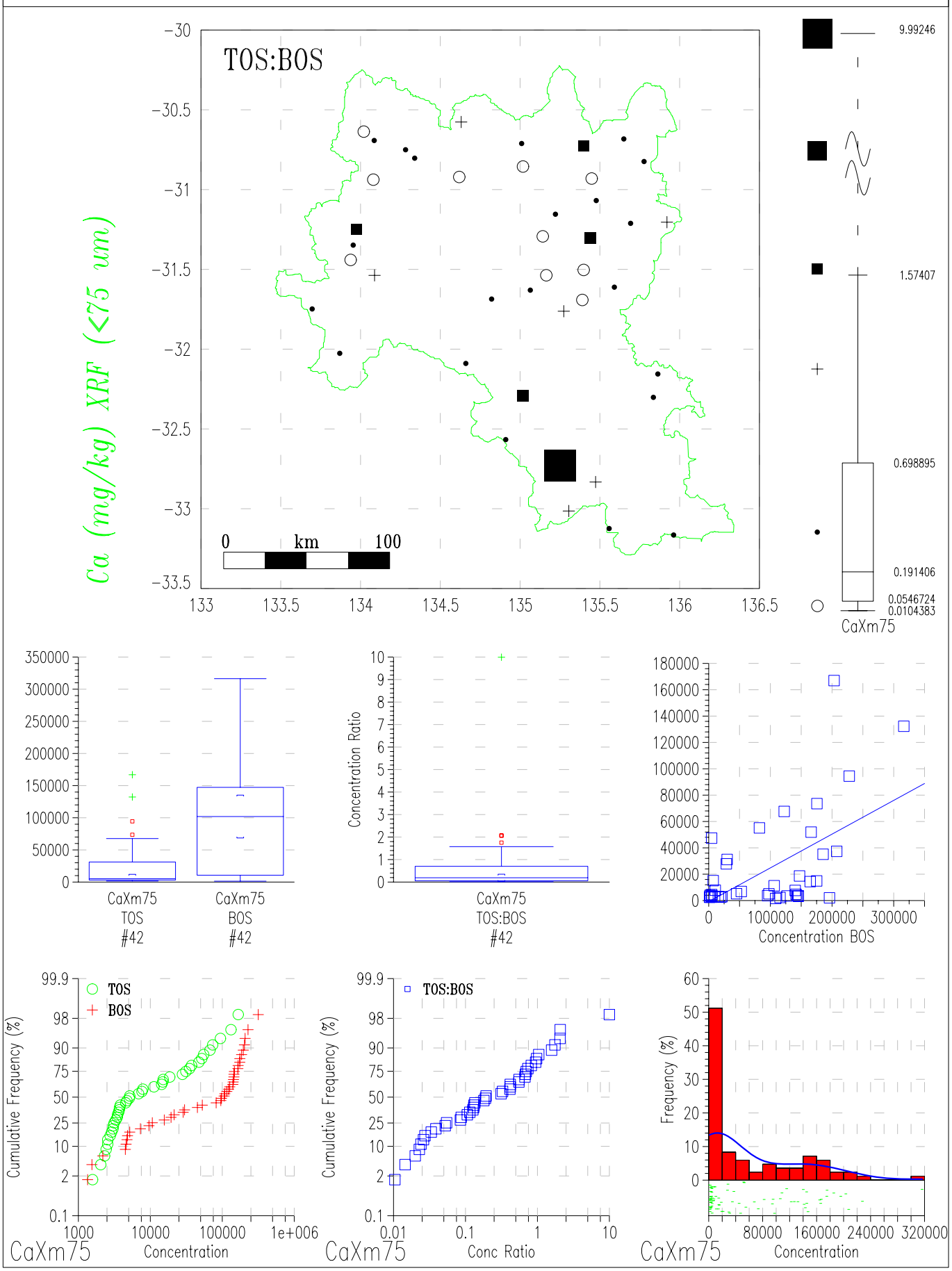

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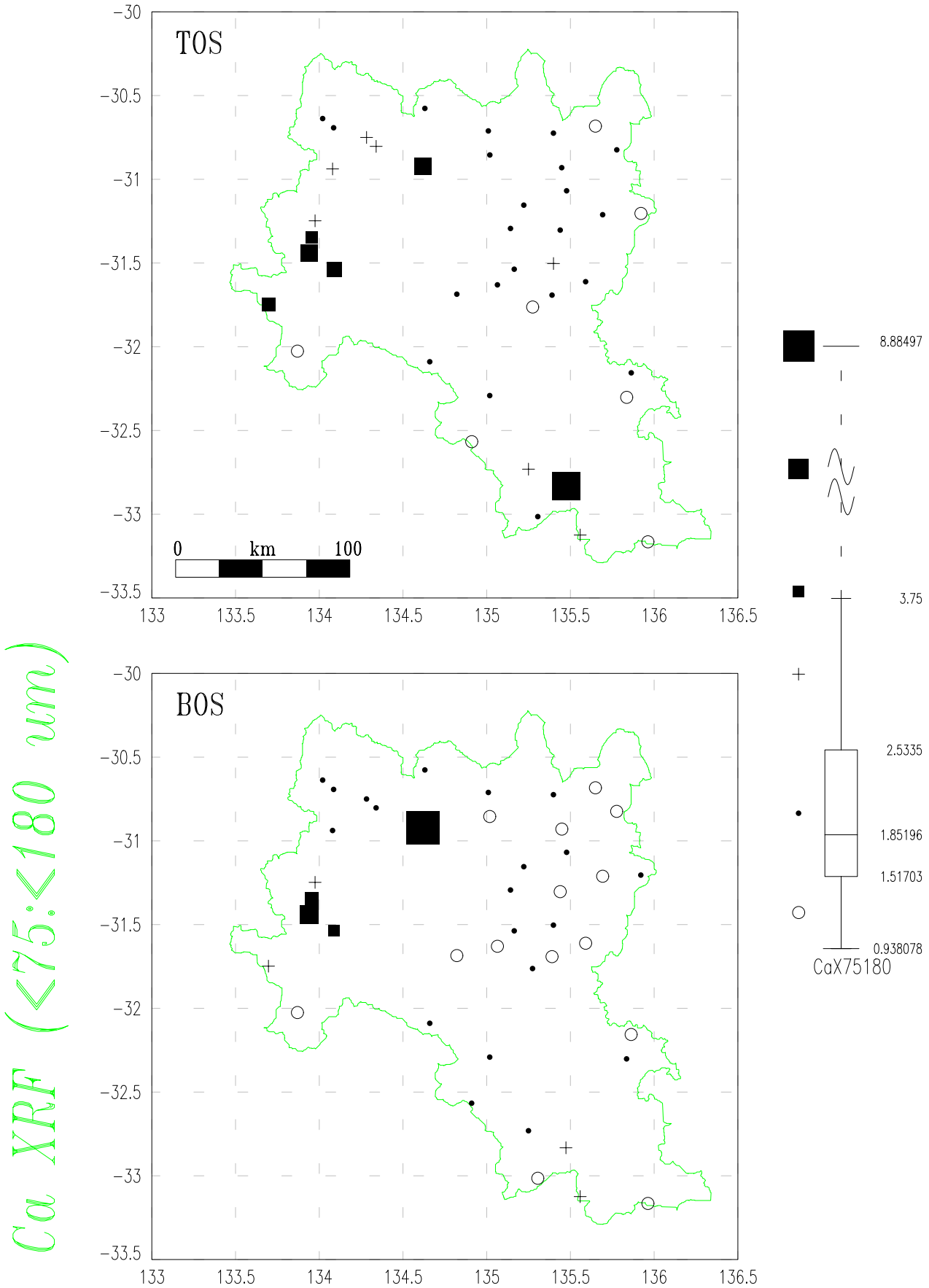

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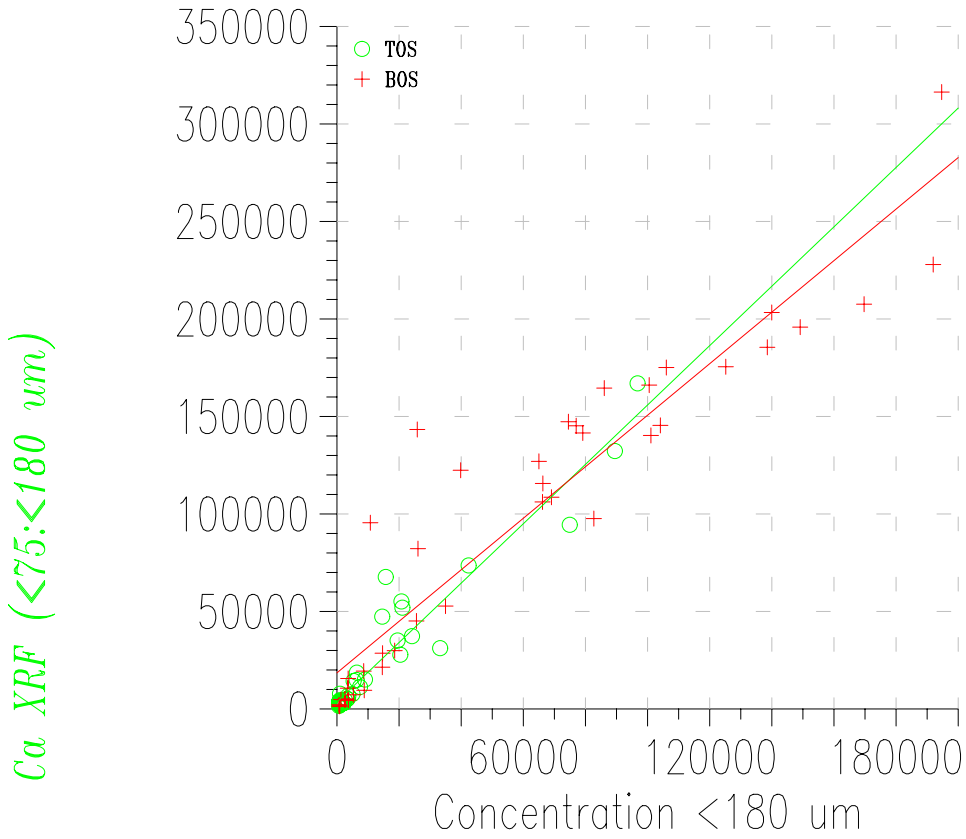
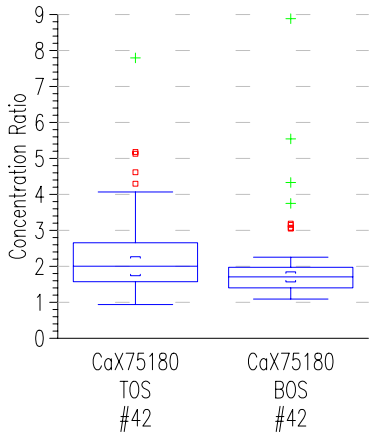
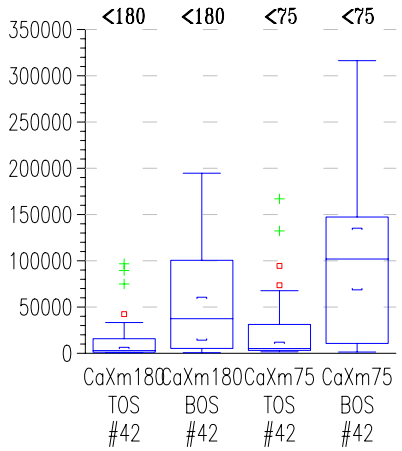
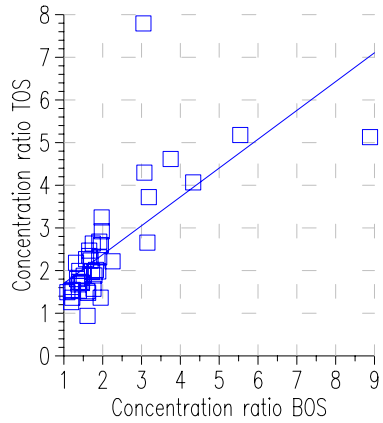
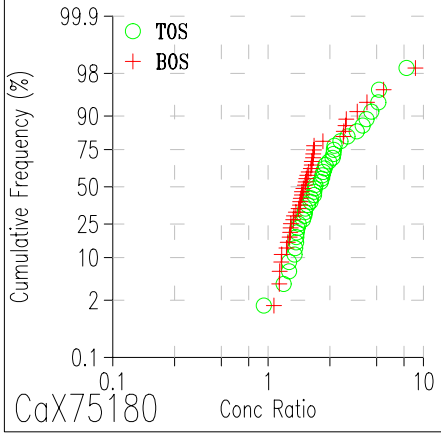
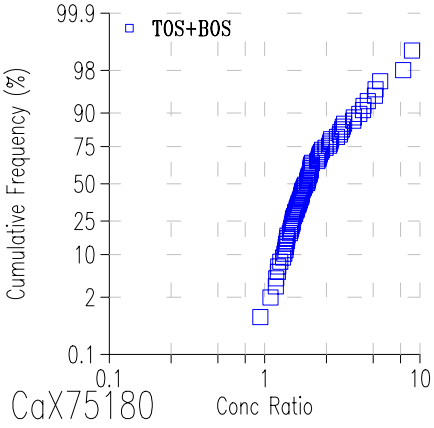


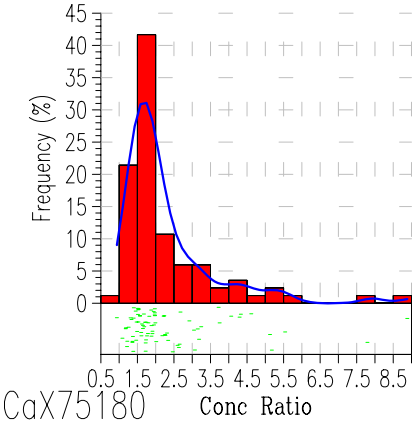






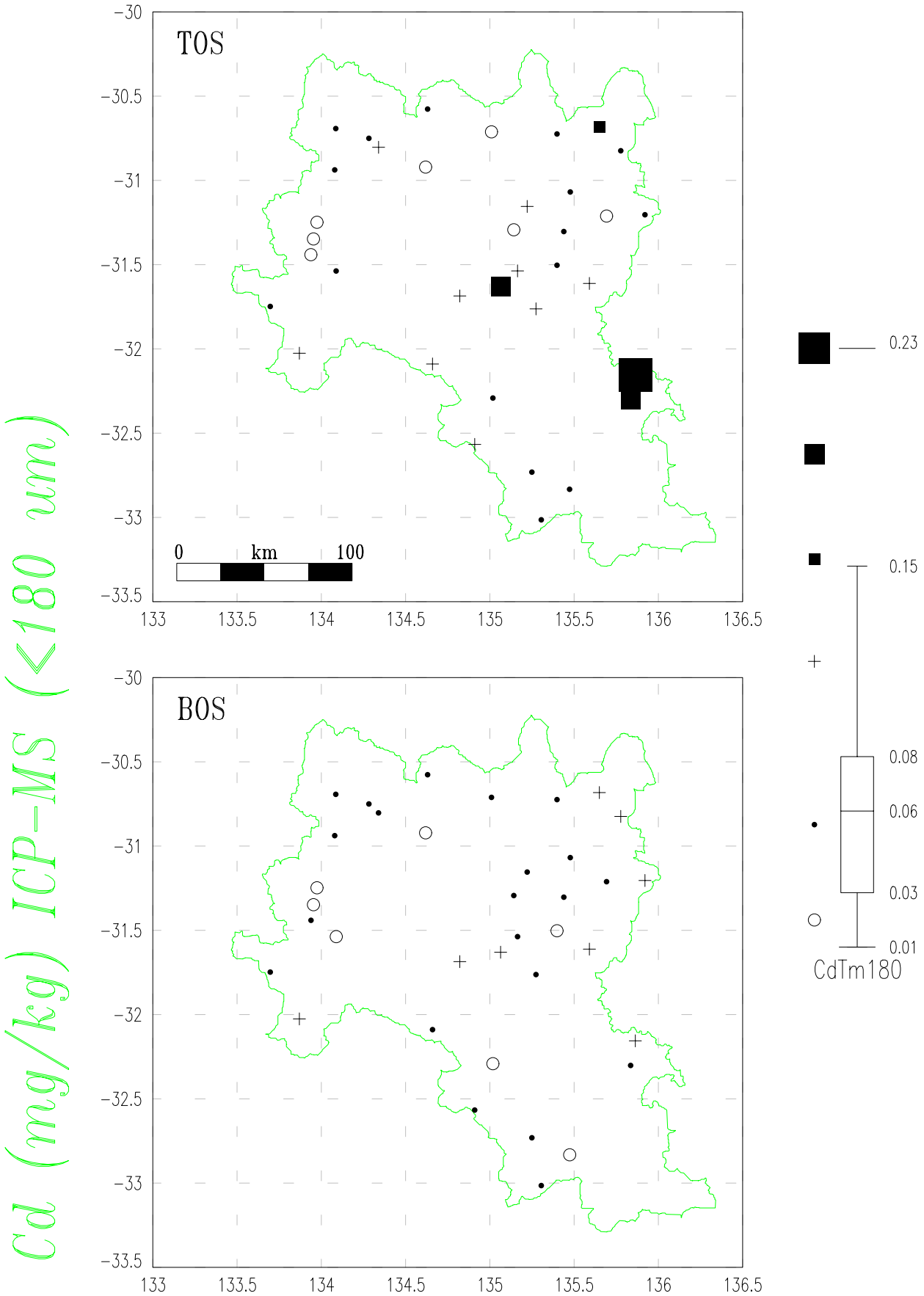






GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



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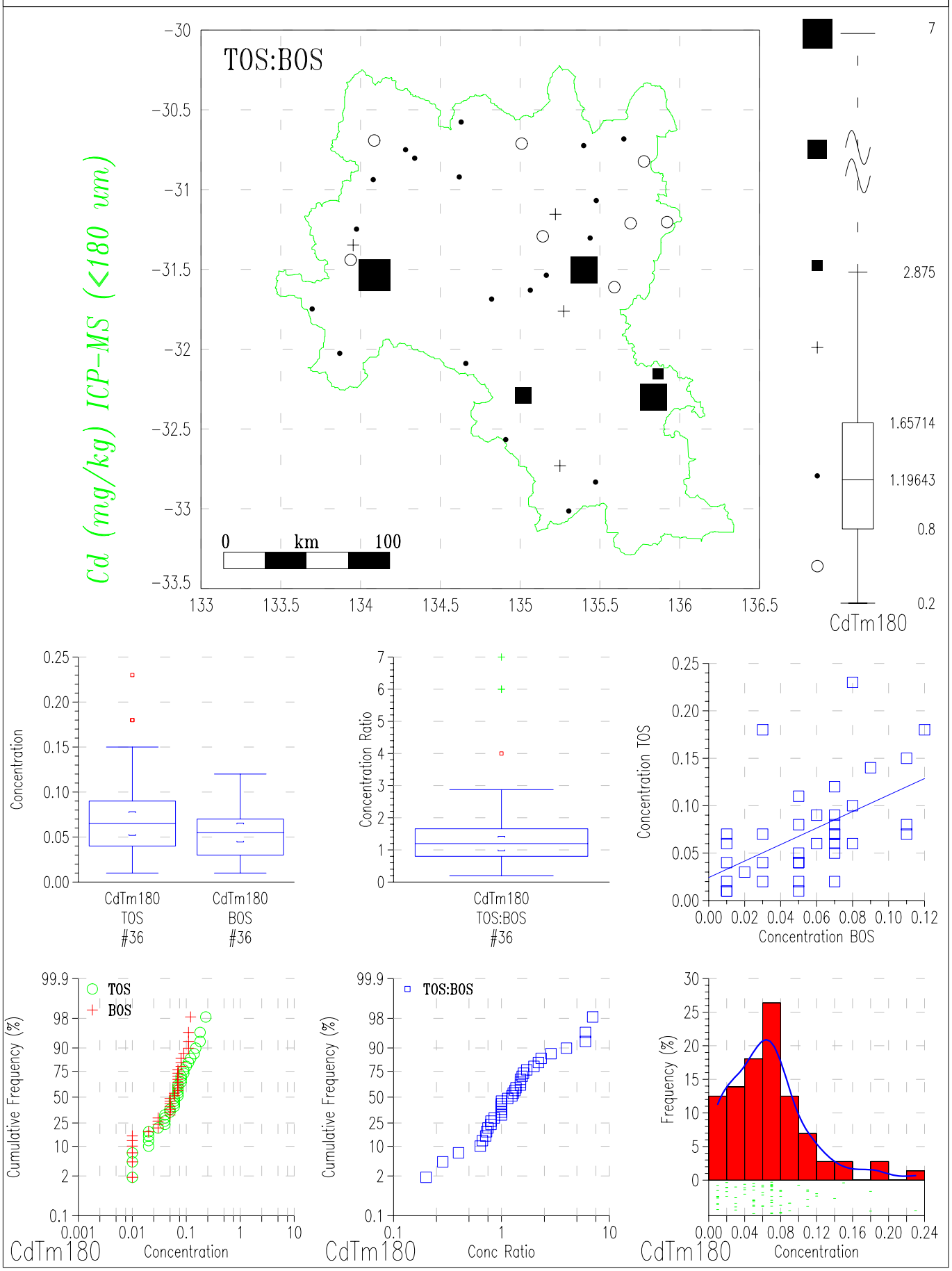

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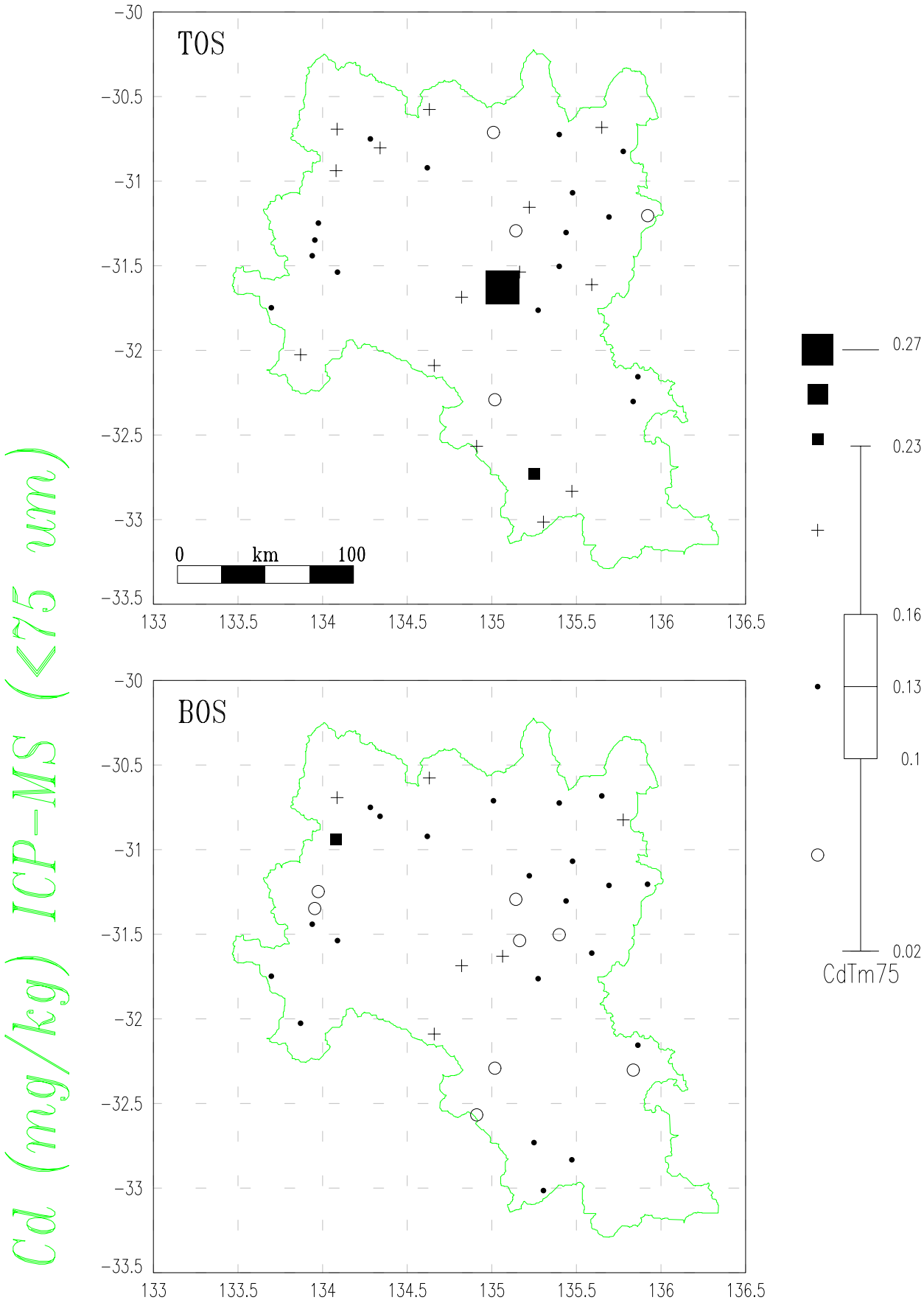

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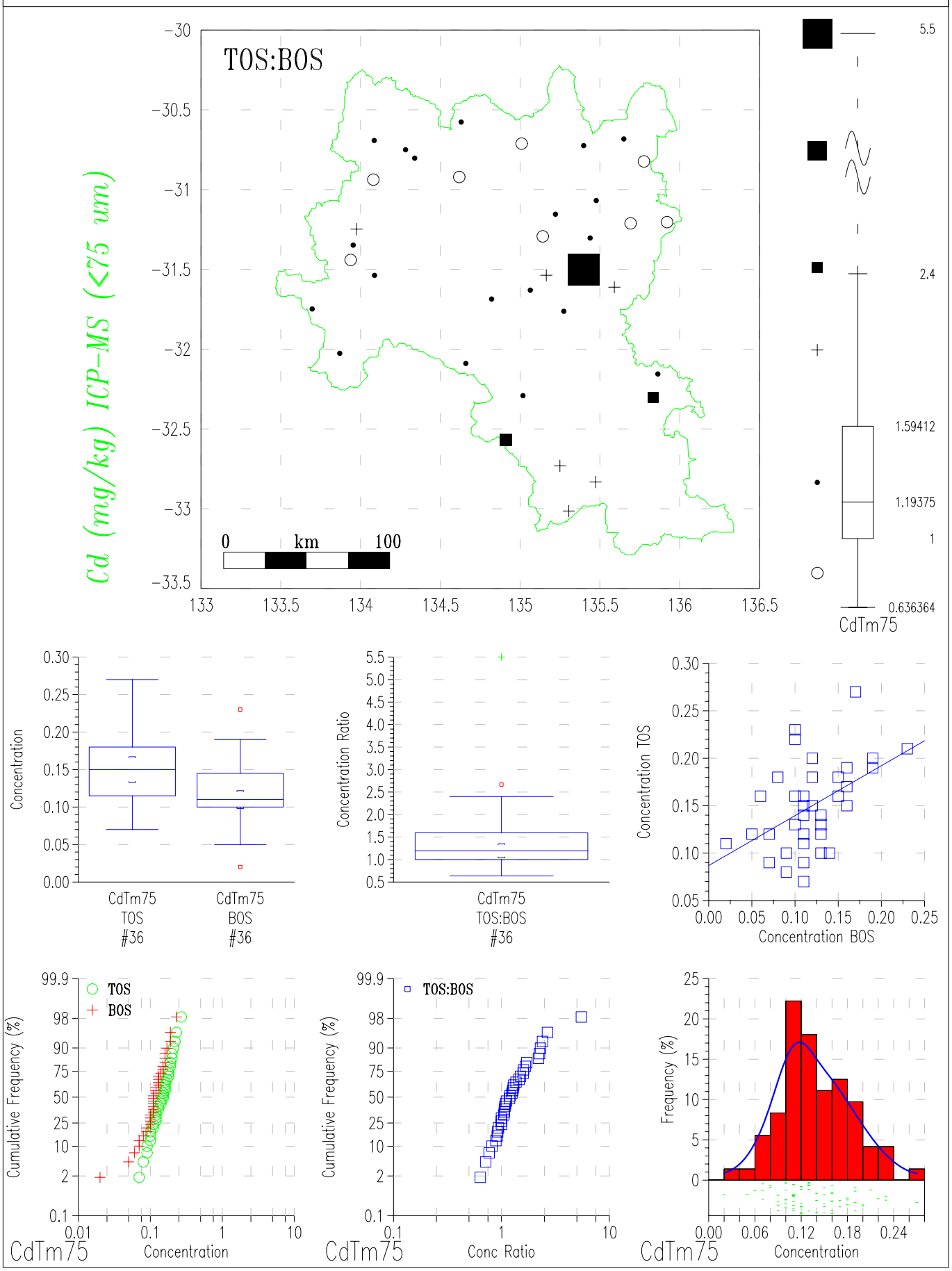

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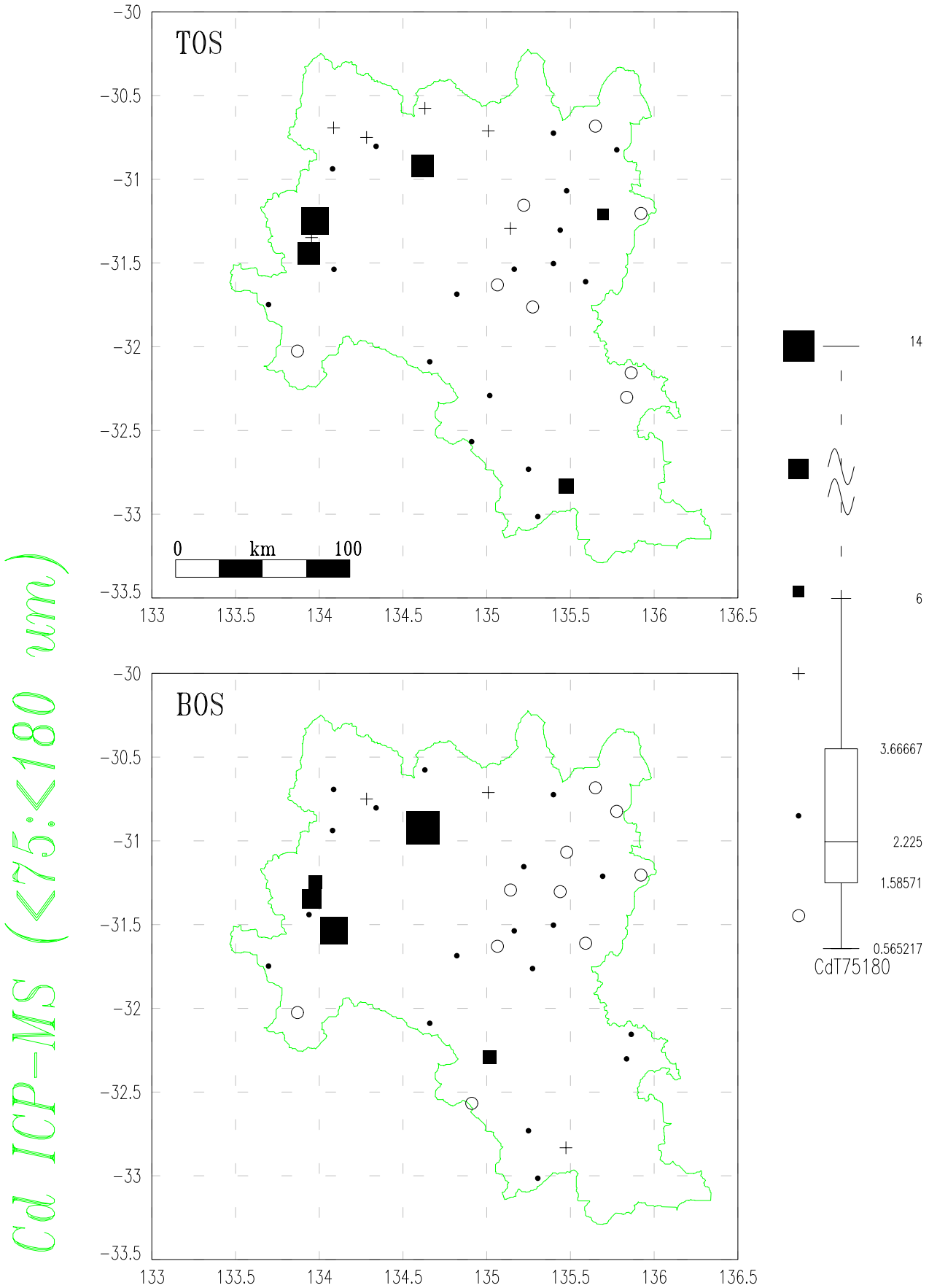

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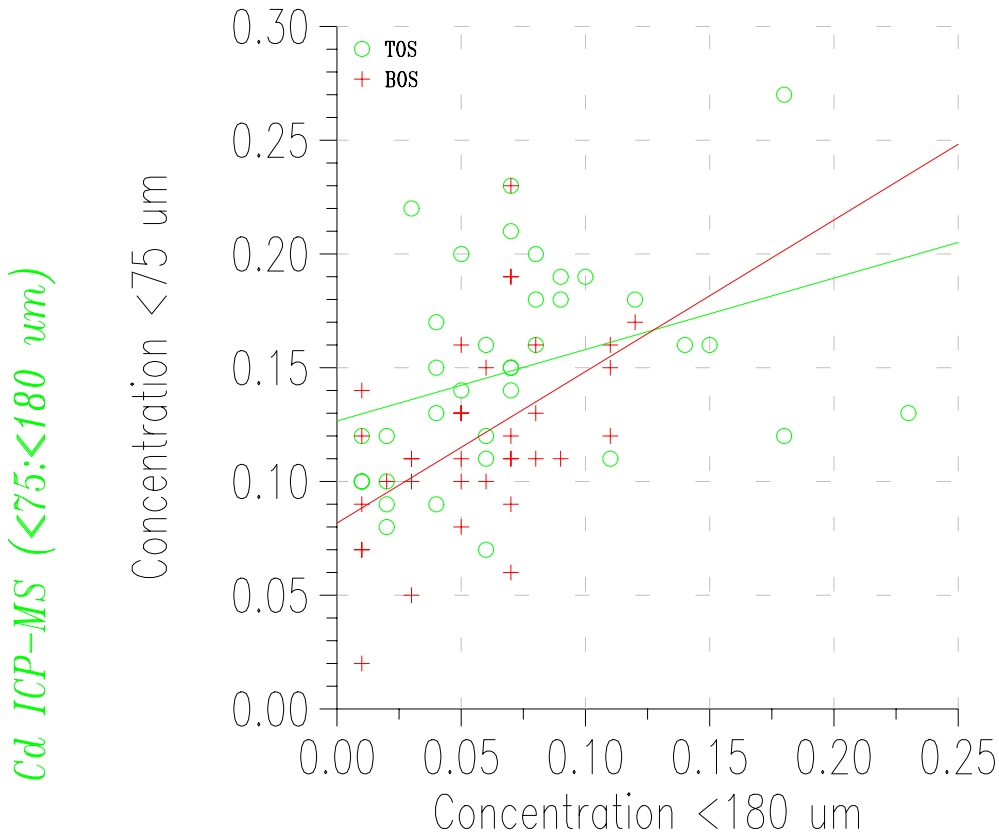
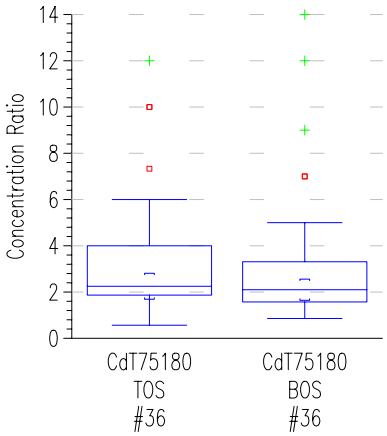
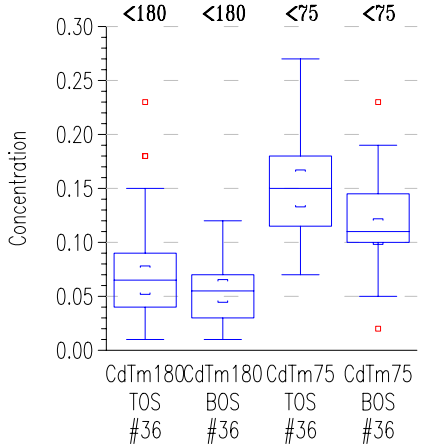
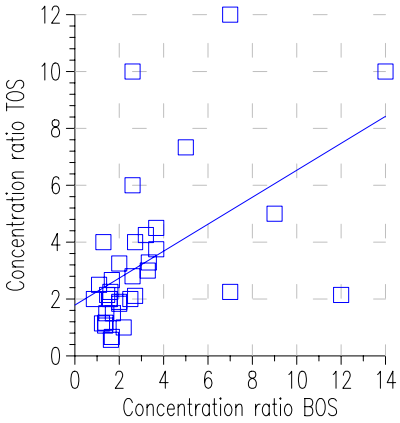
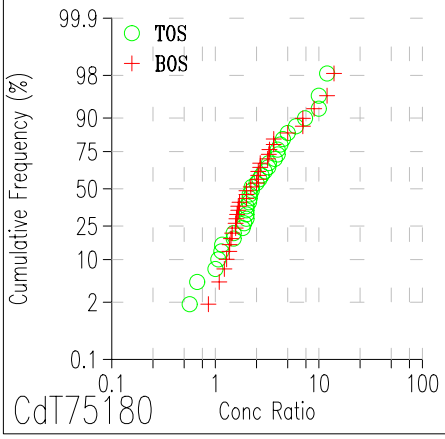
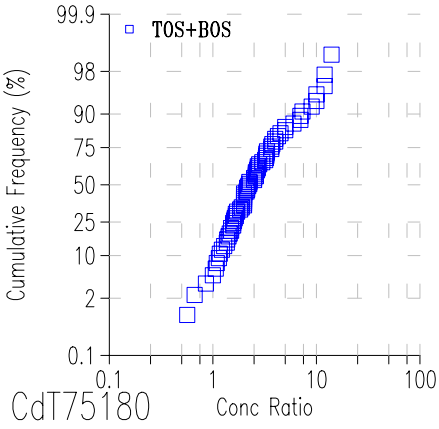


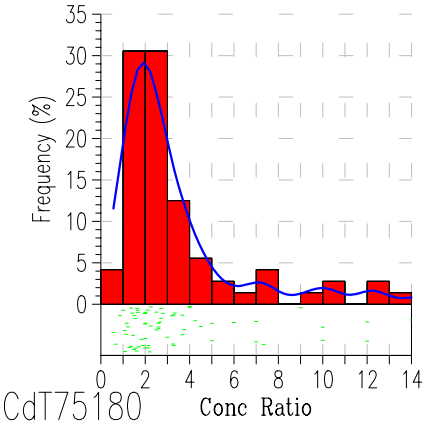






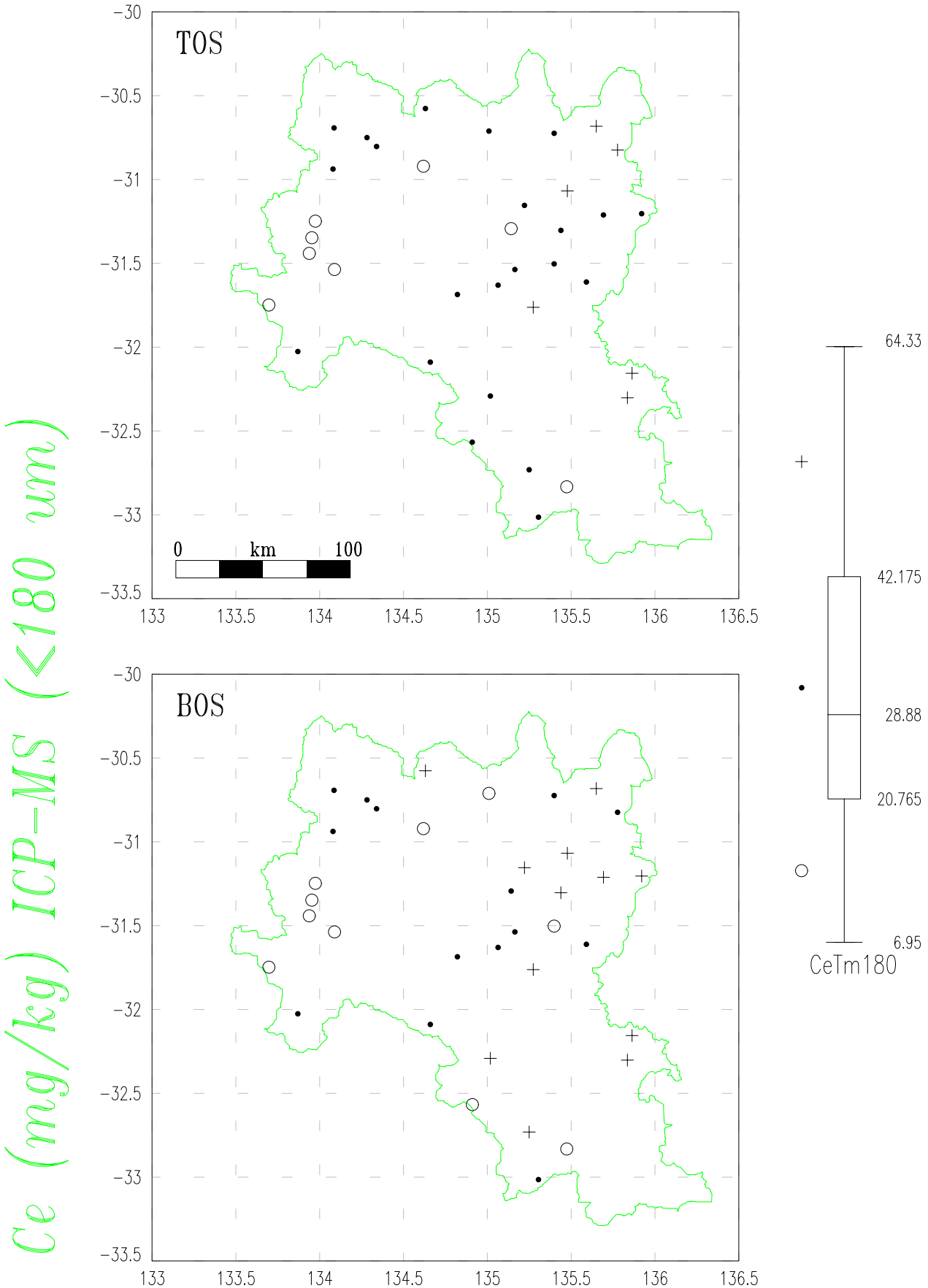






GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



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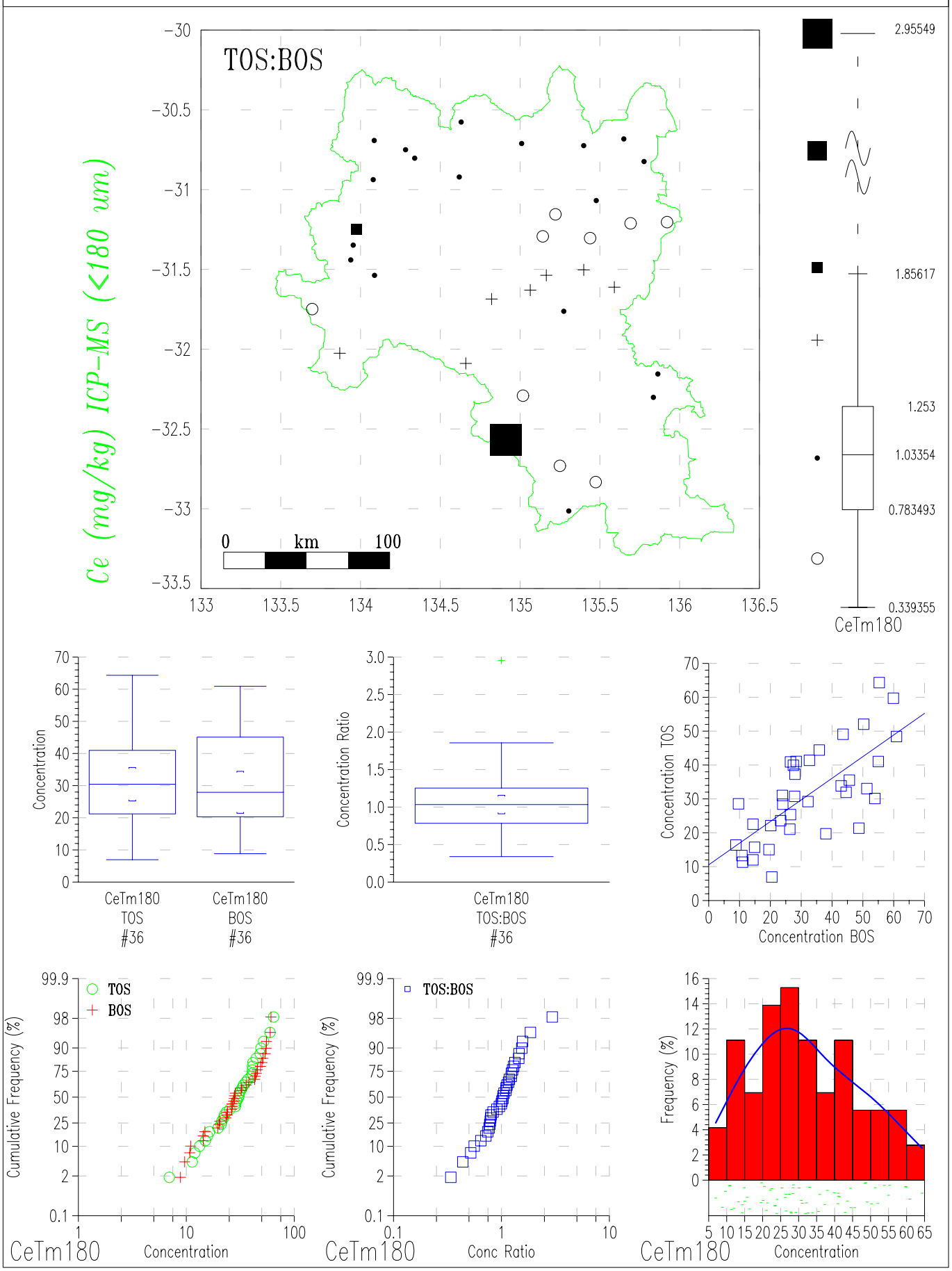

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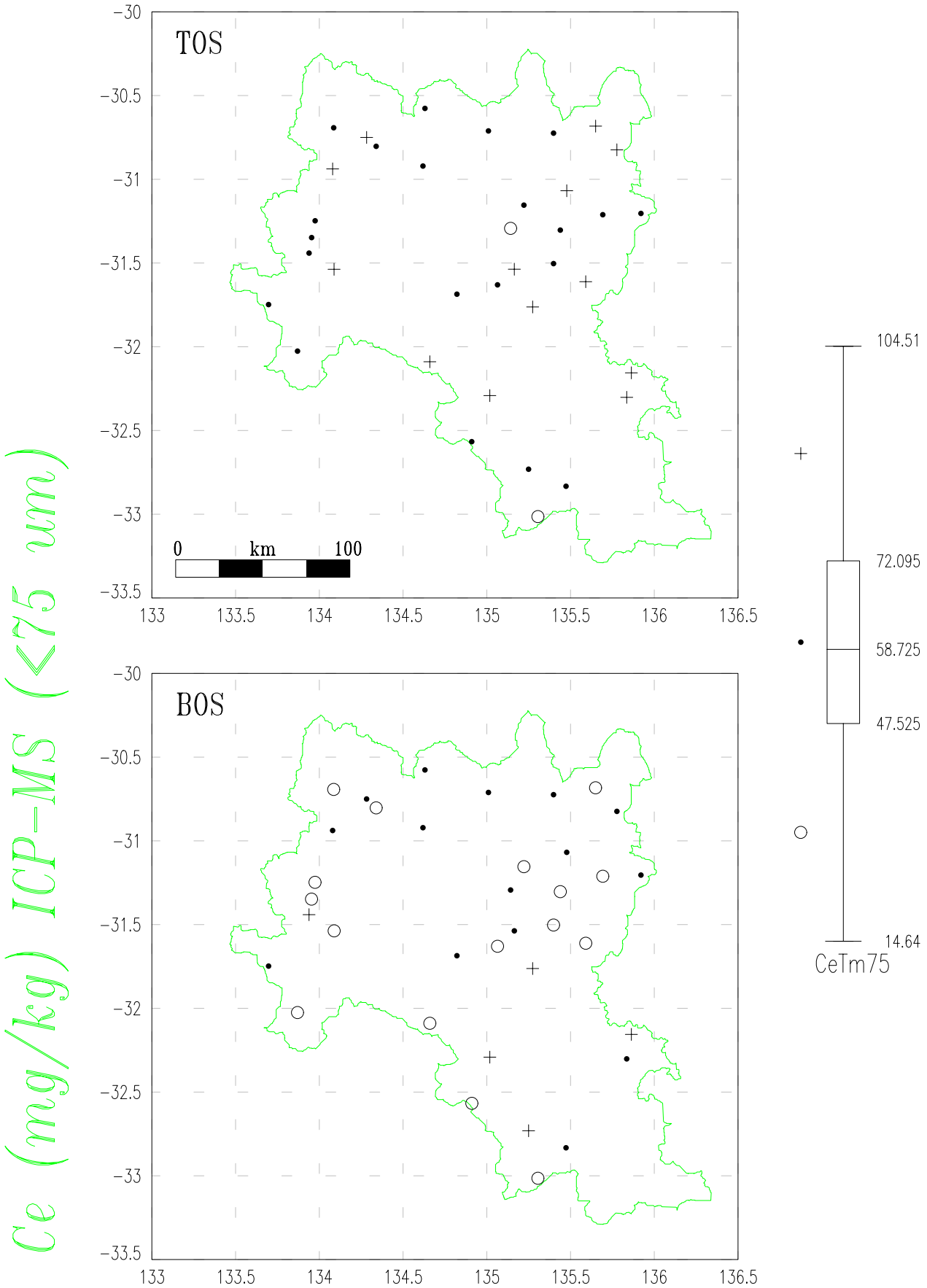

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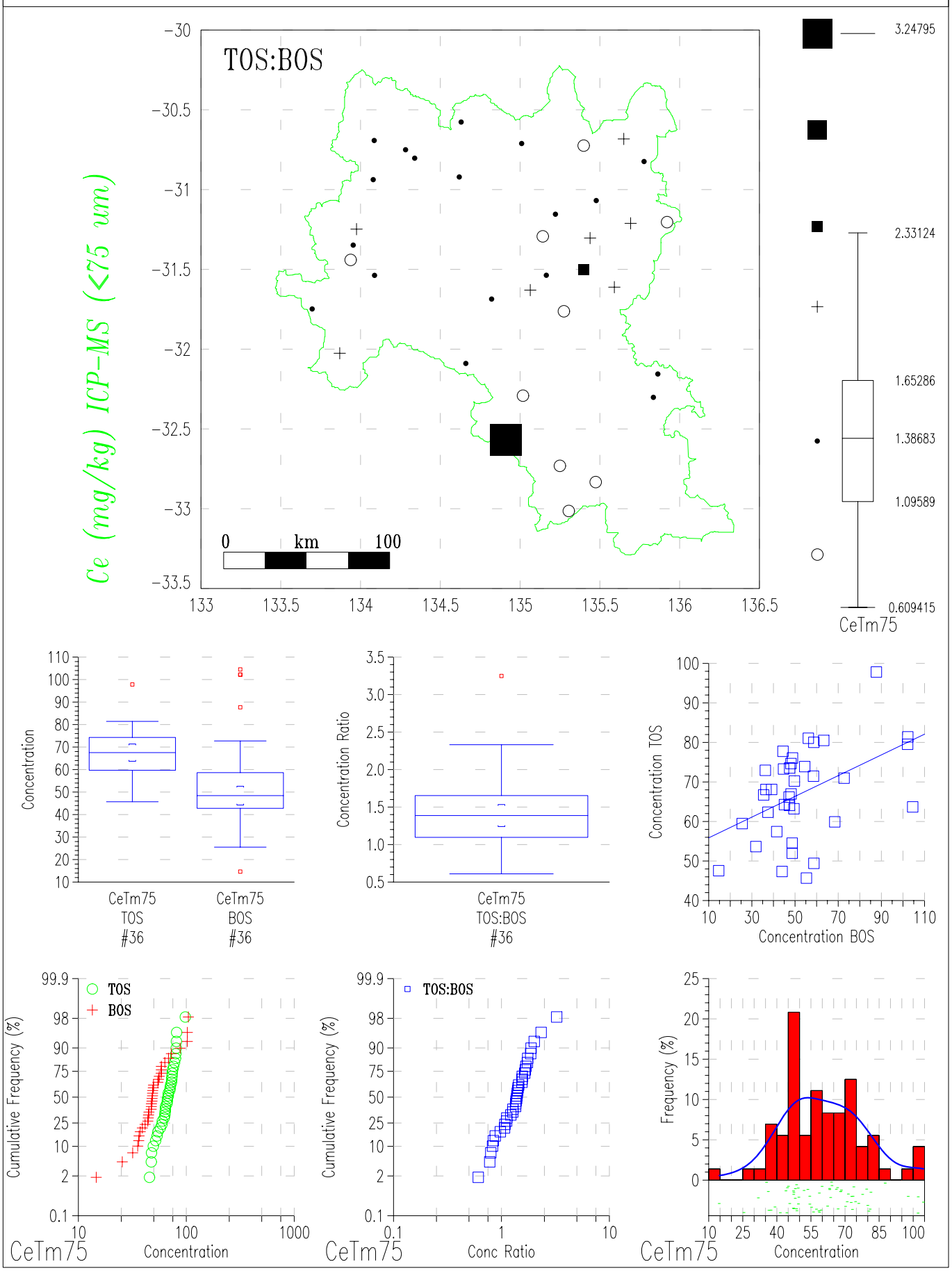

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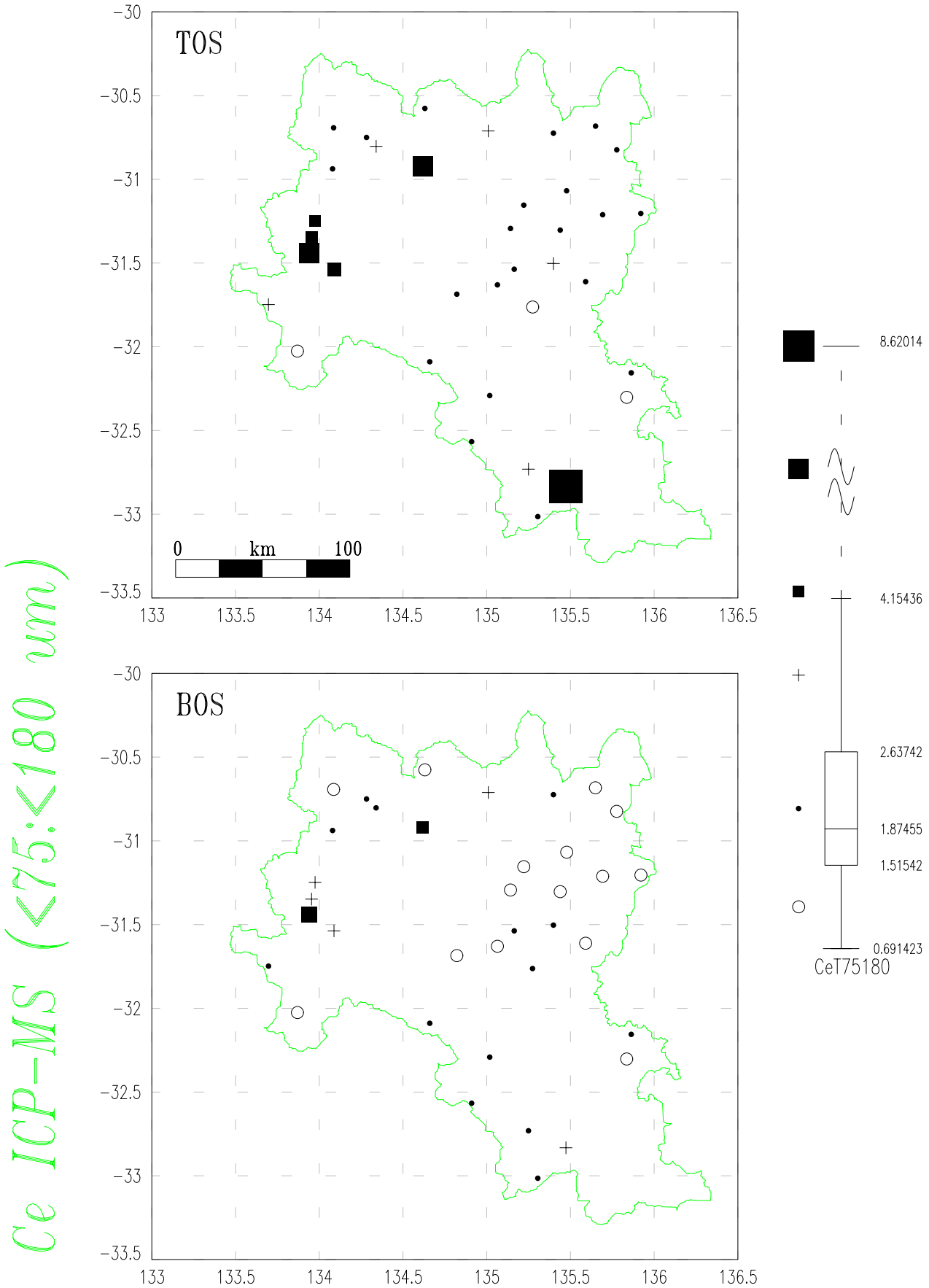

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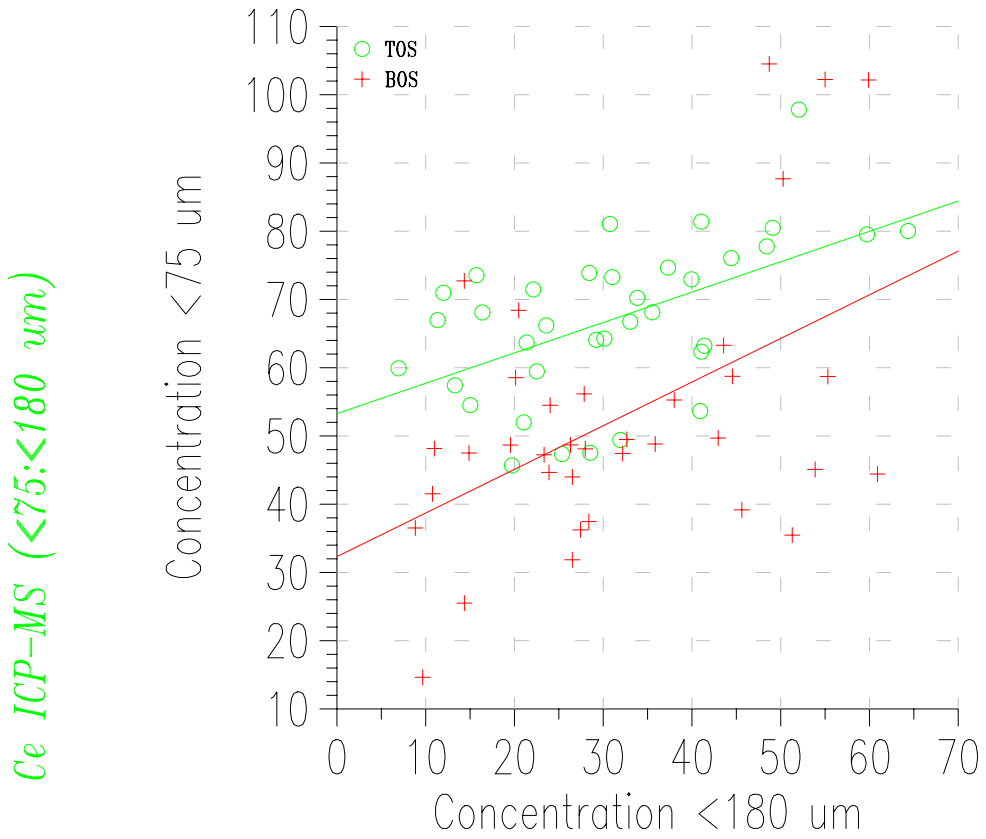

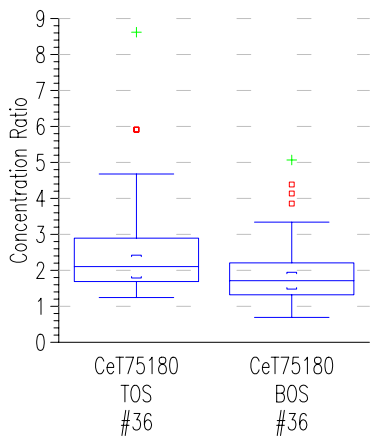

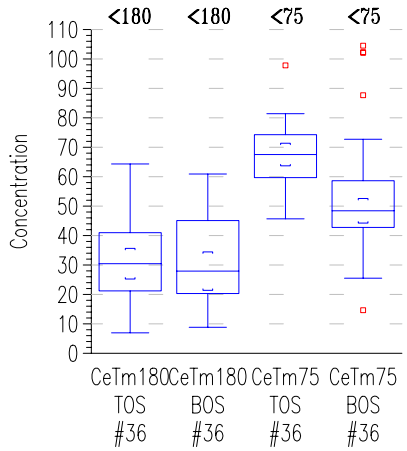

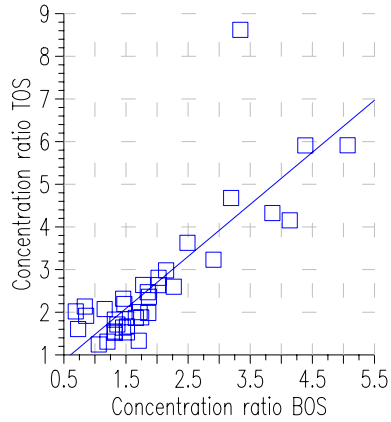

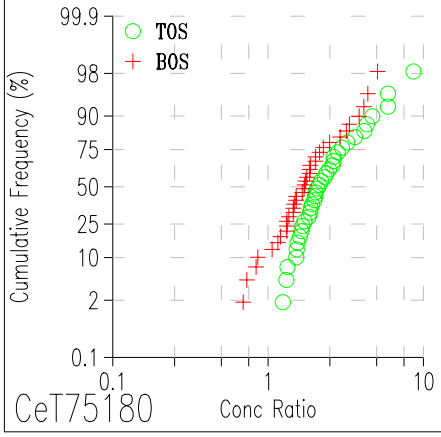

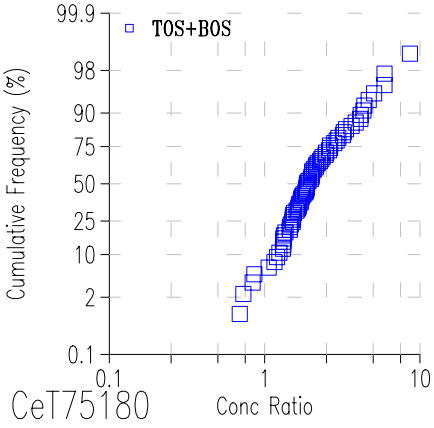

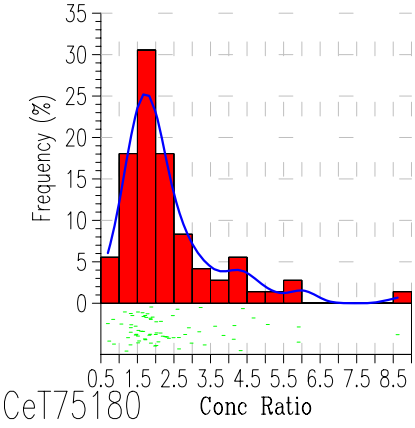

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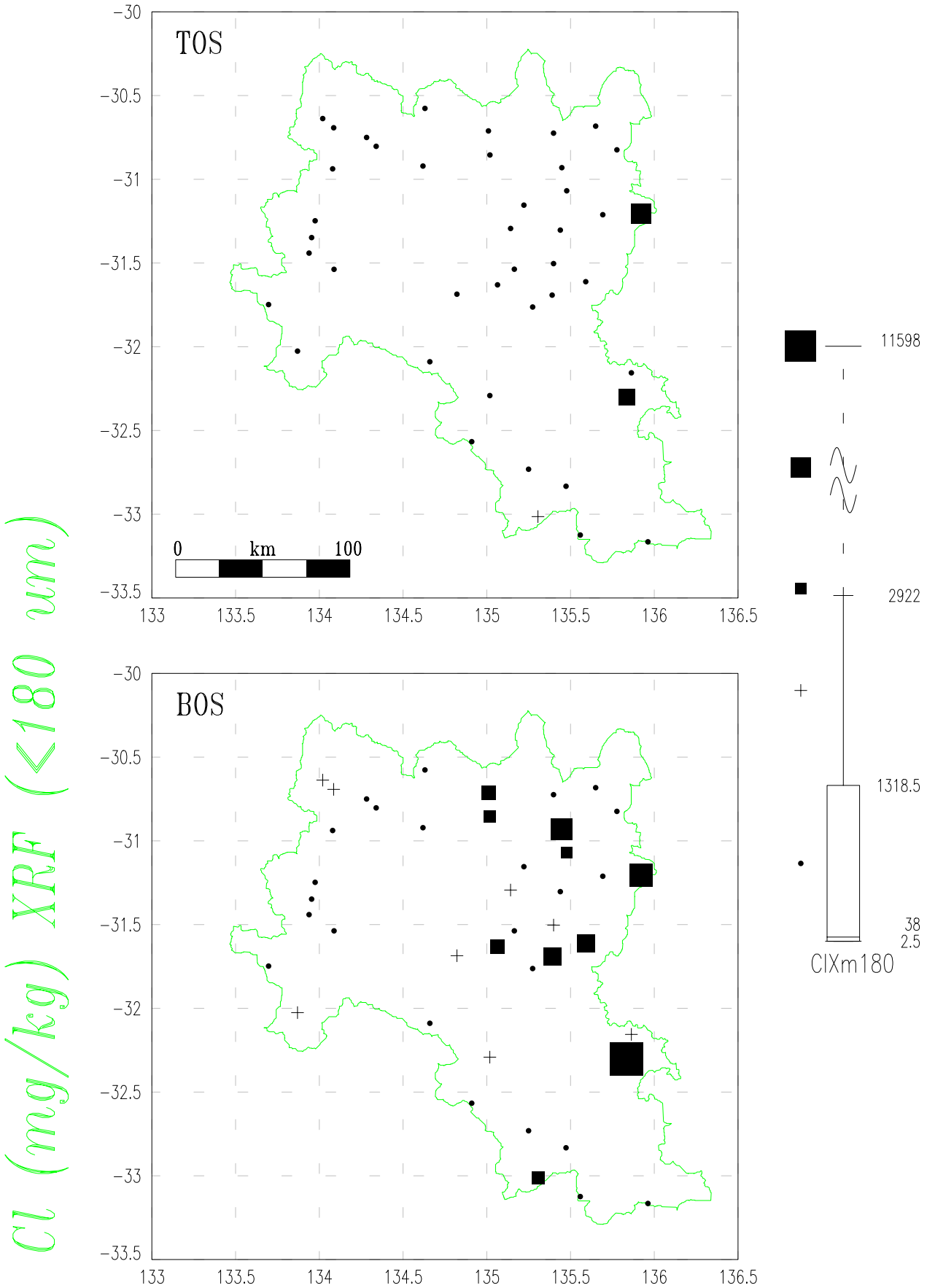
Top & Bottom Outlet Sediments (TOS & BOS)



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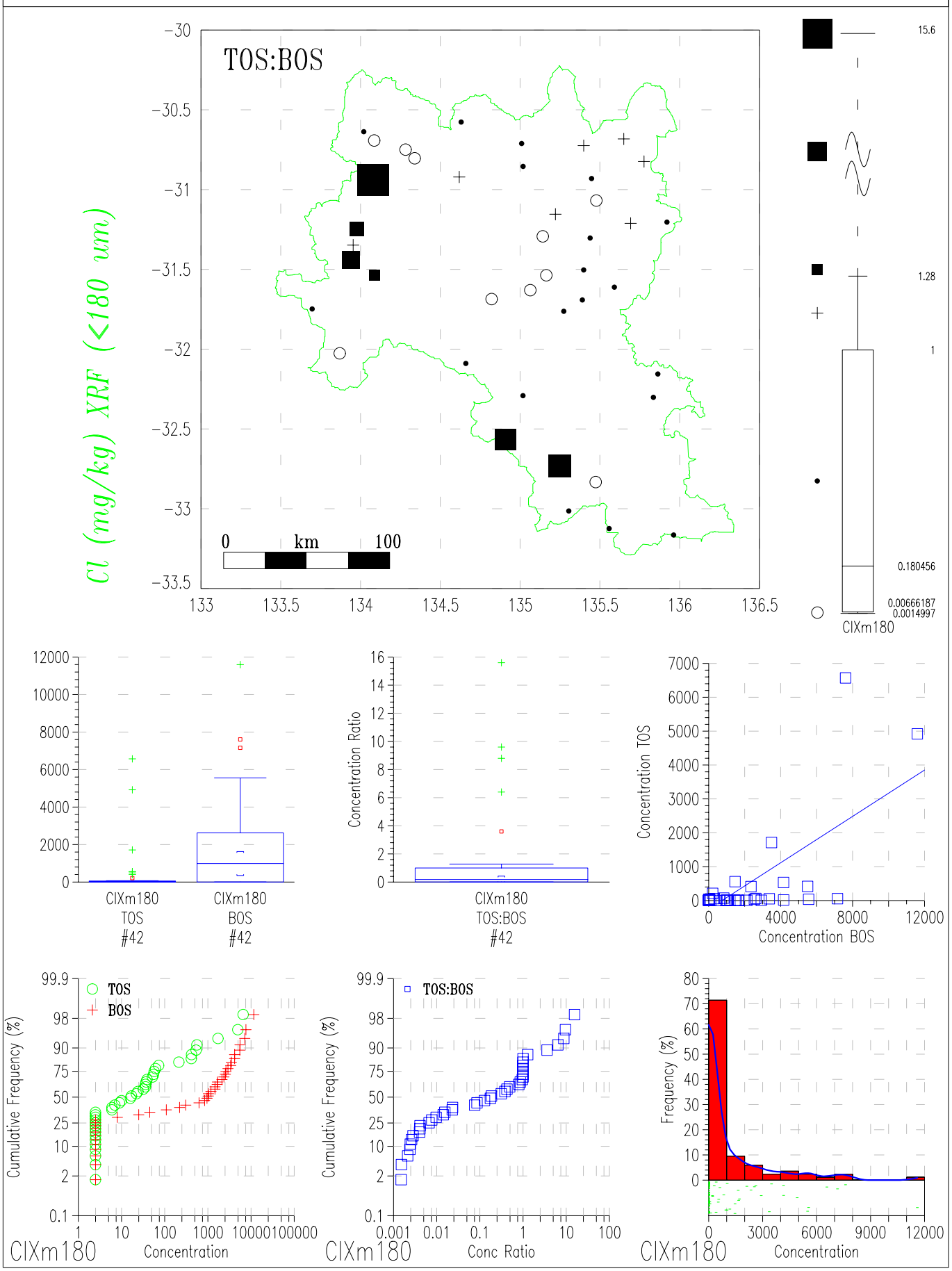

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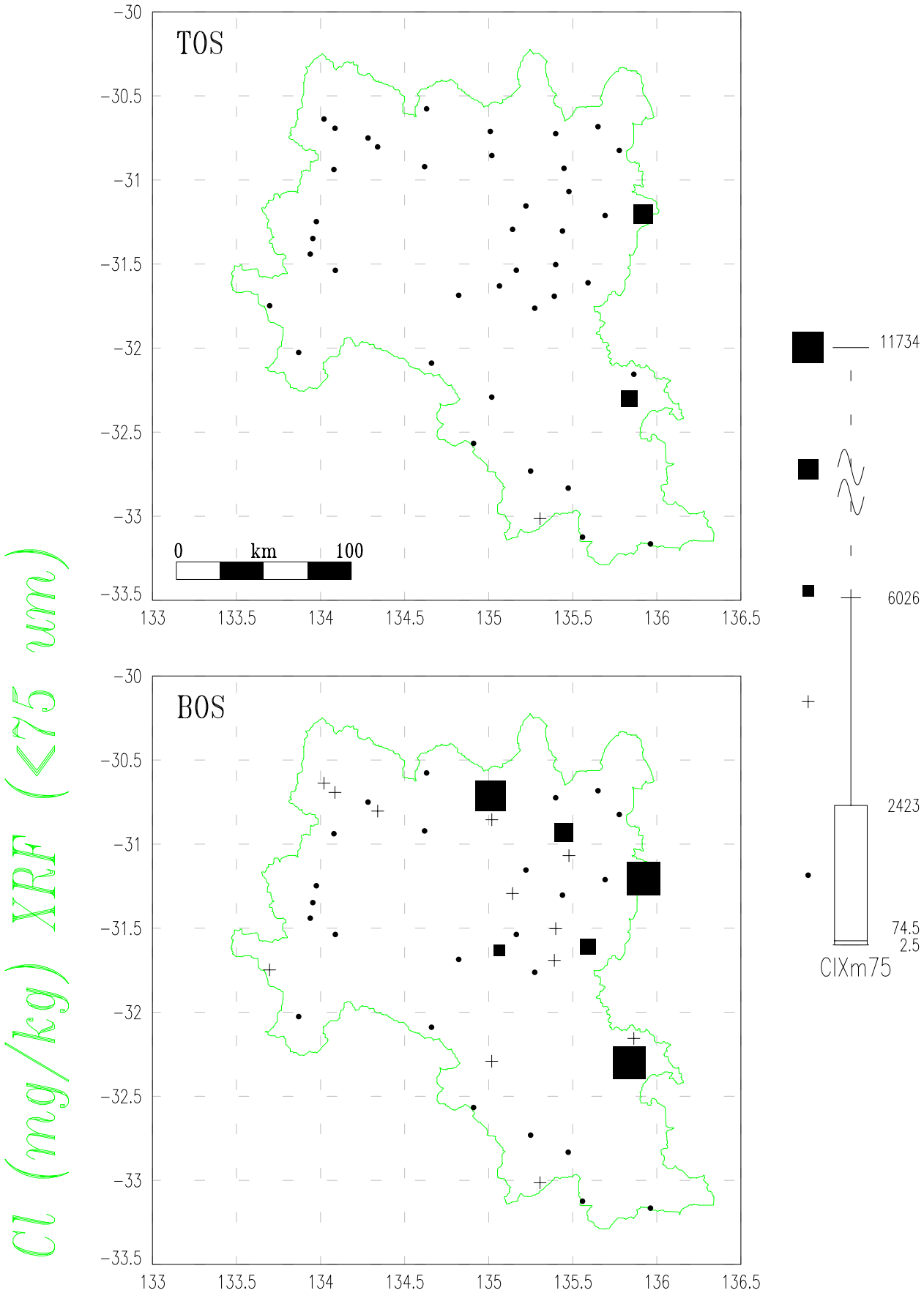

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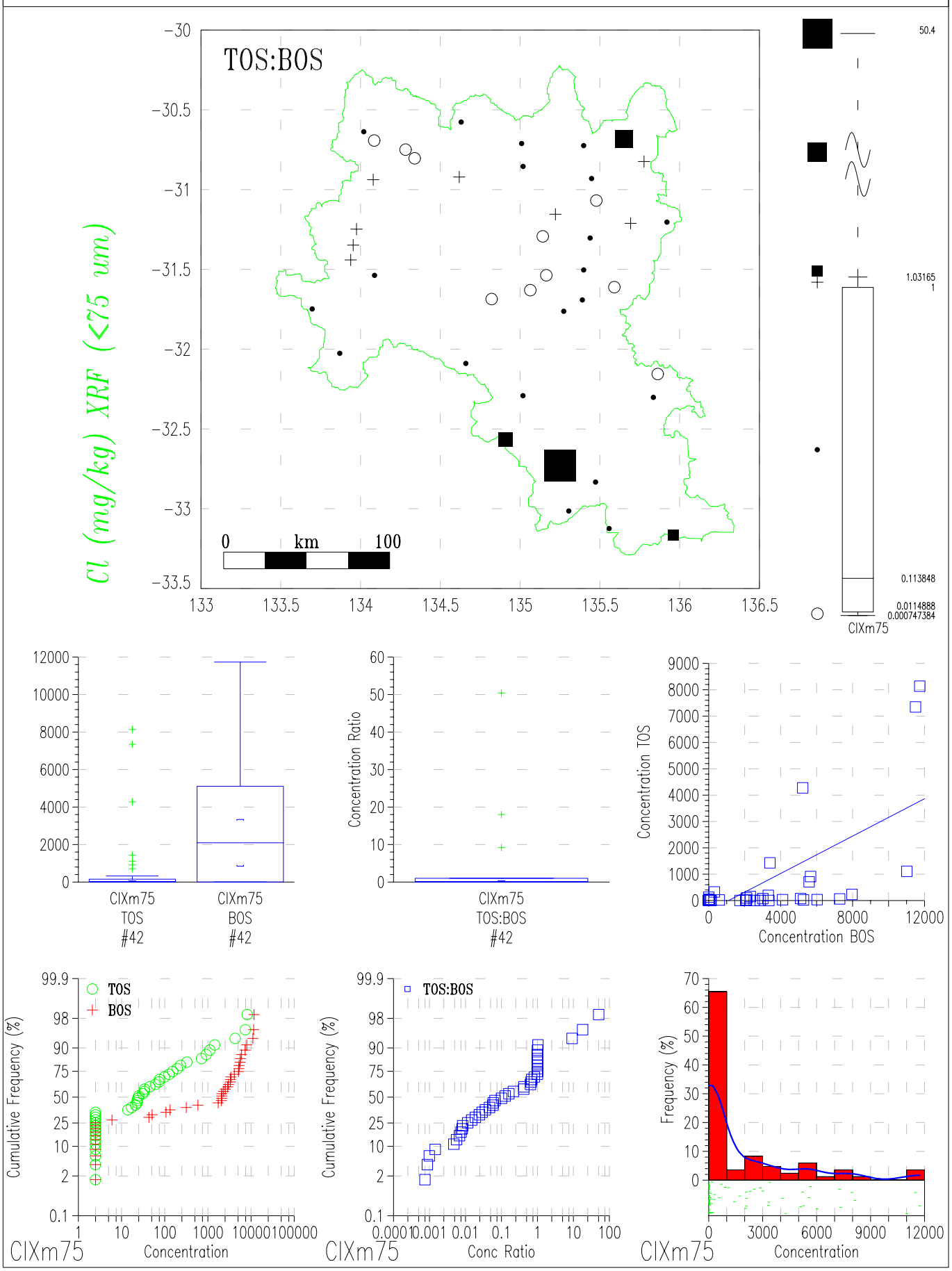

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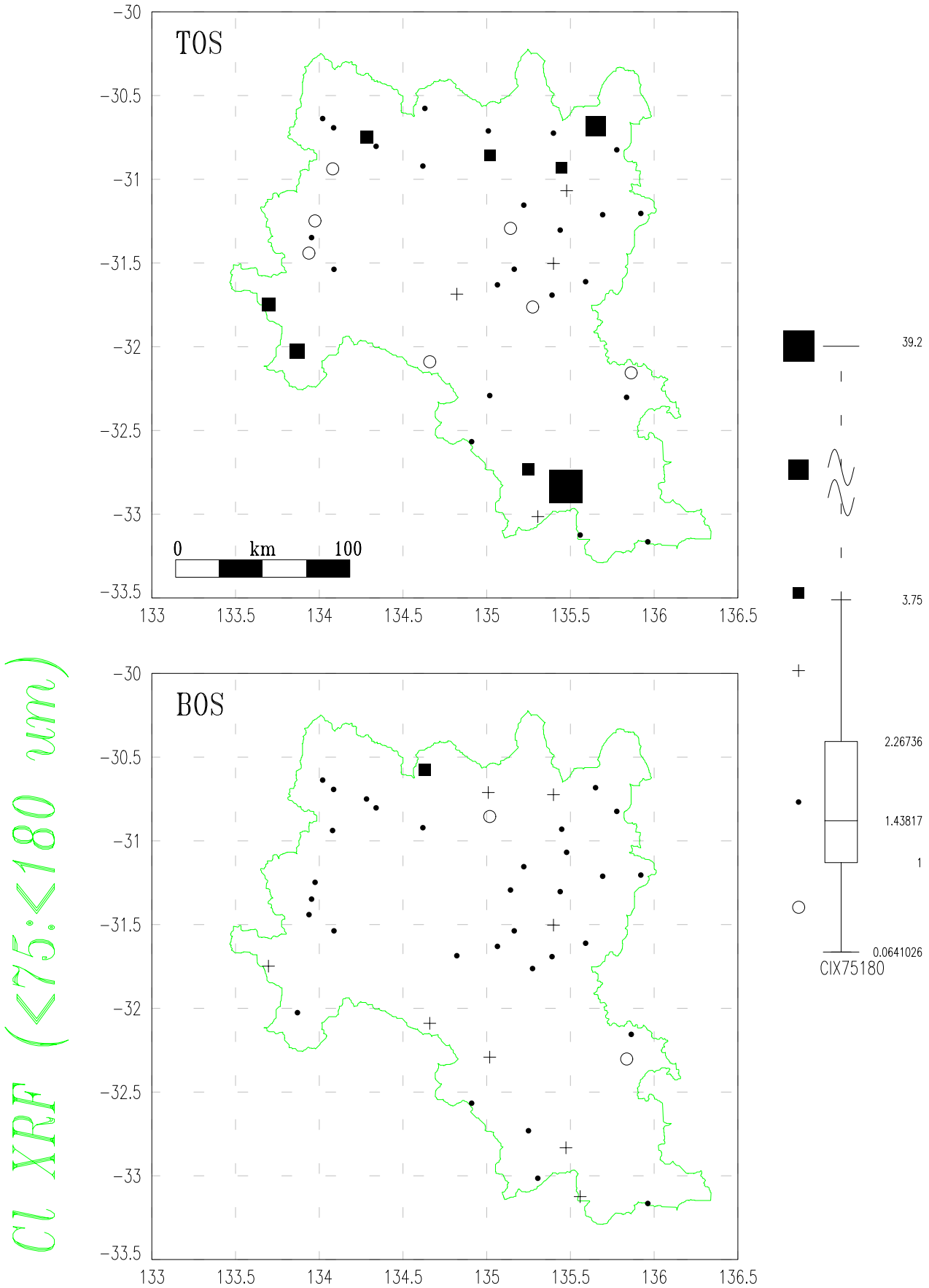

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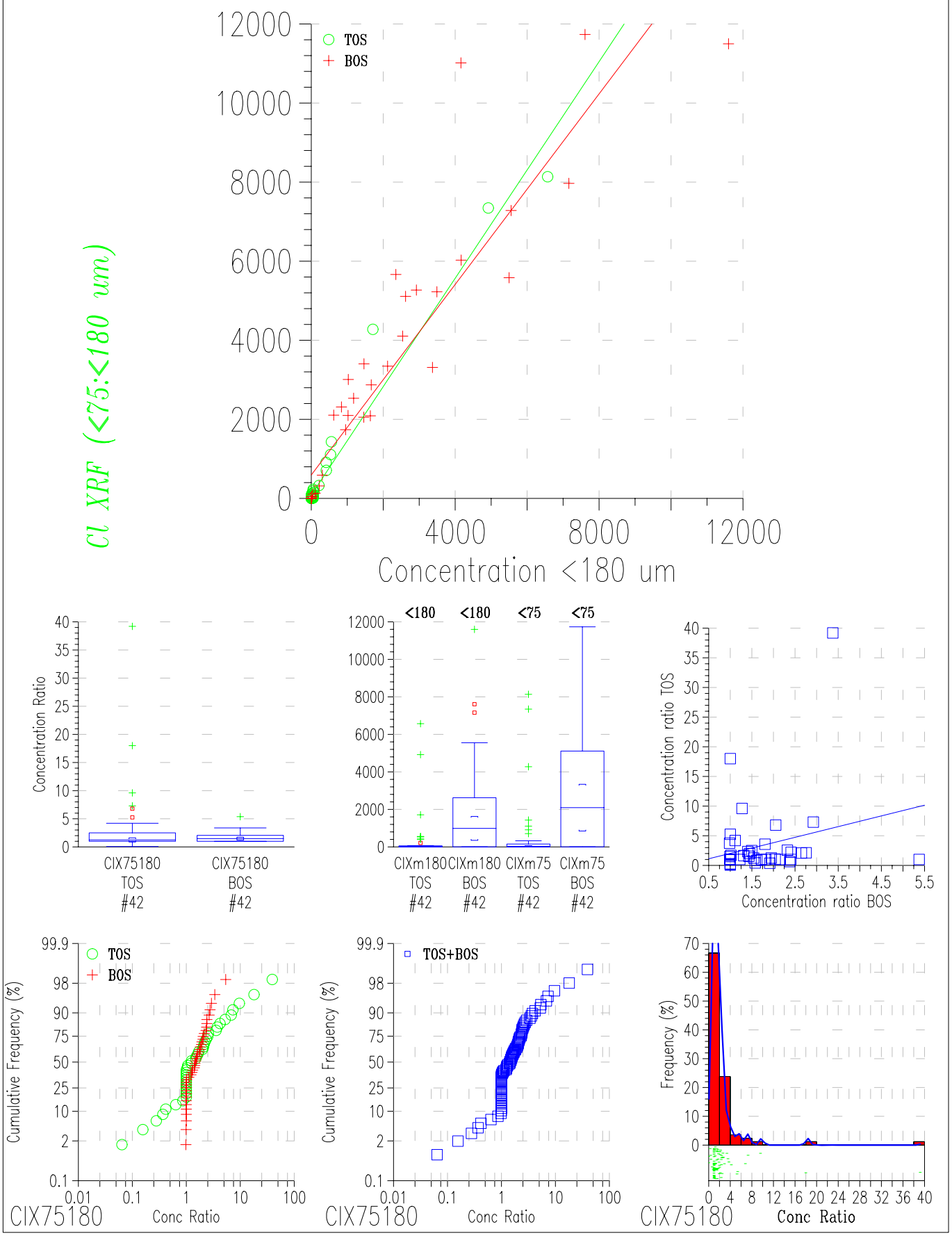
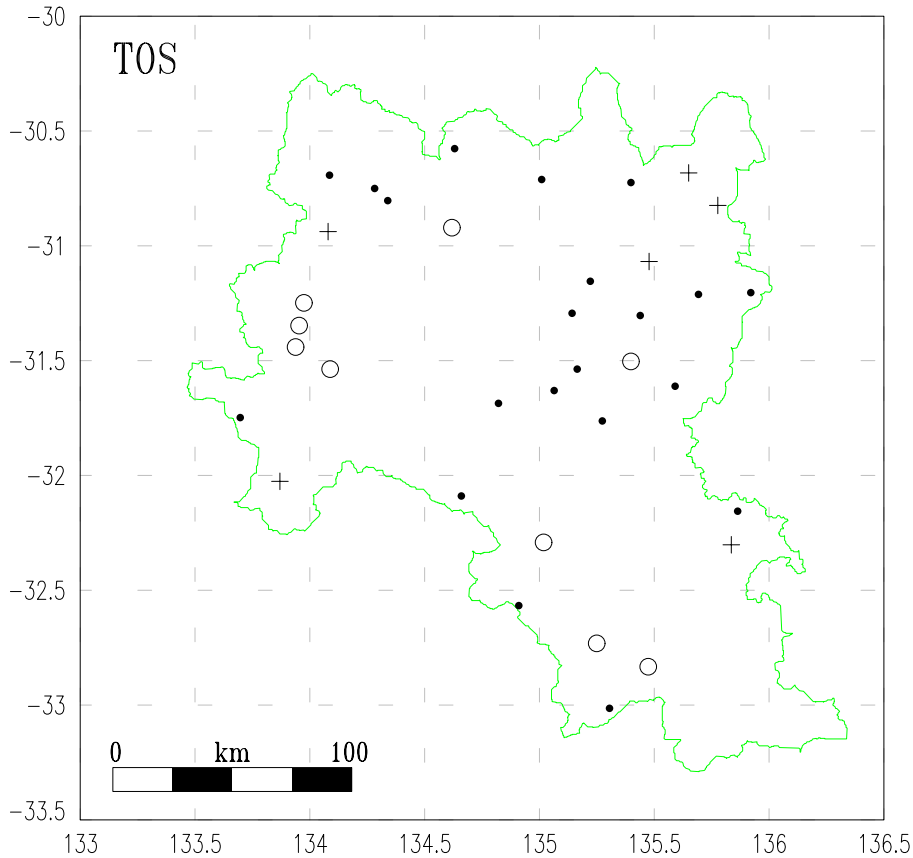
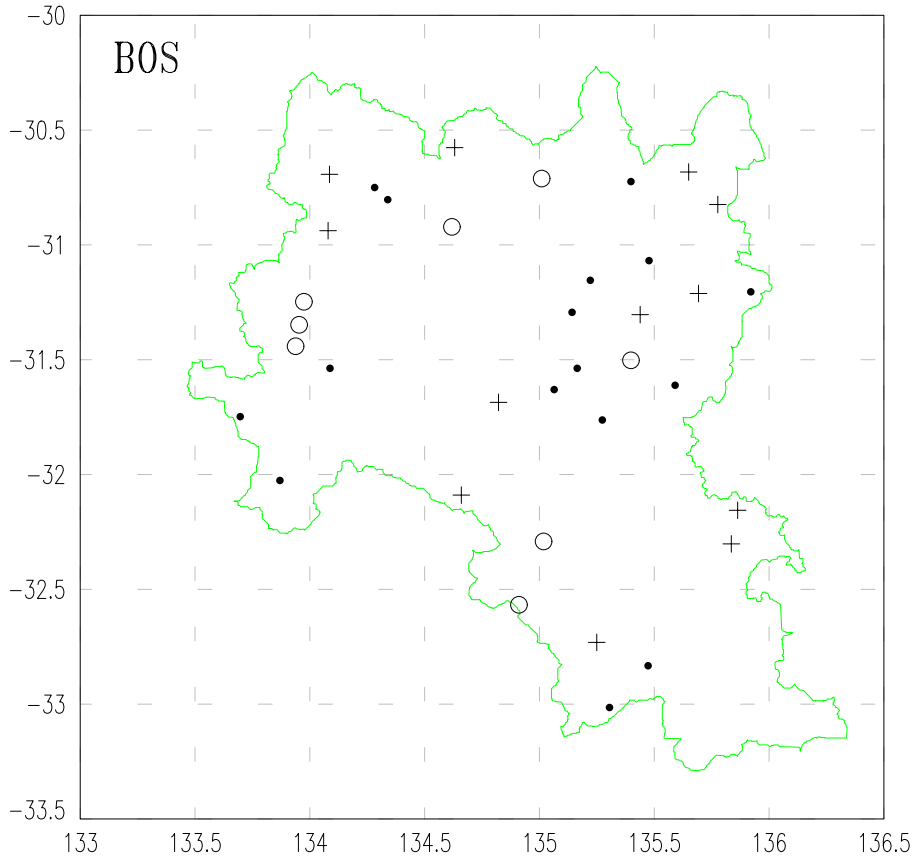


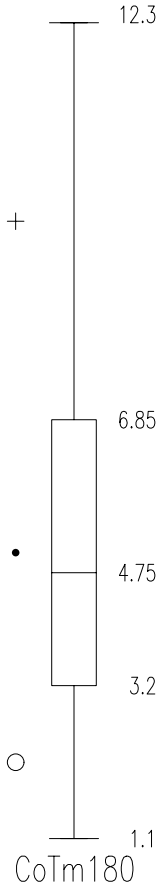
GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)

Co (mg/kg) ICP-MS (<180 um)

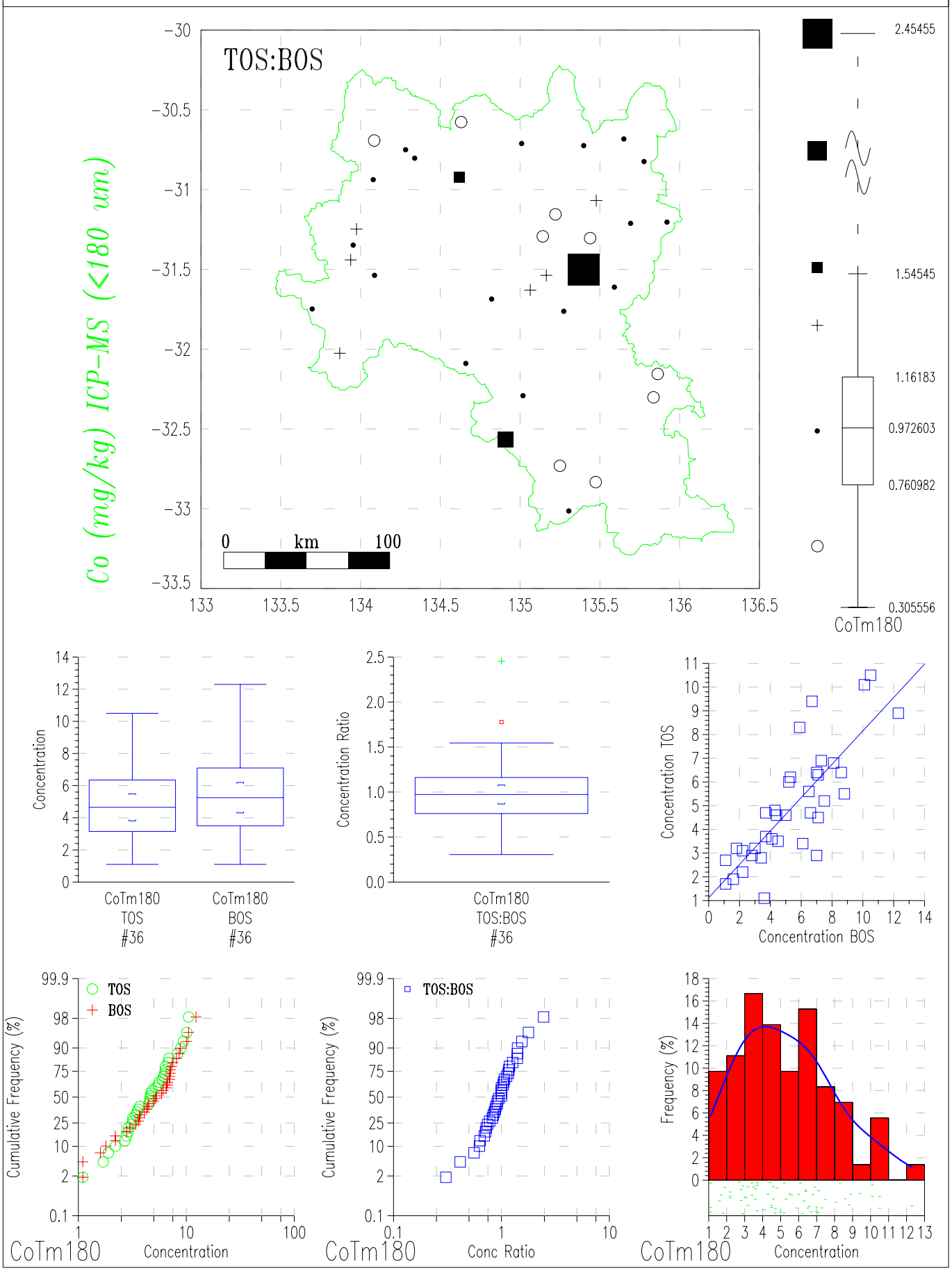






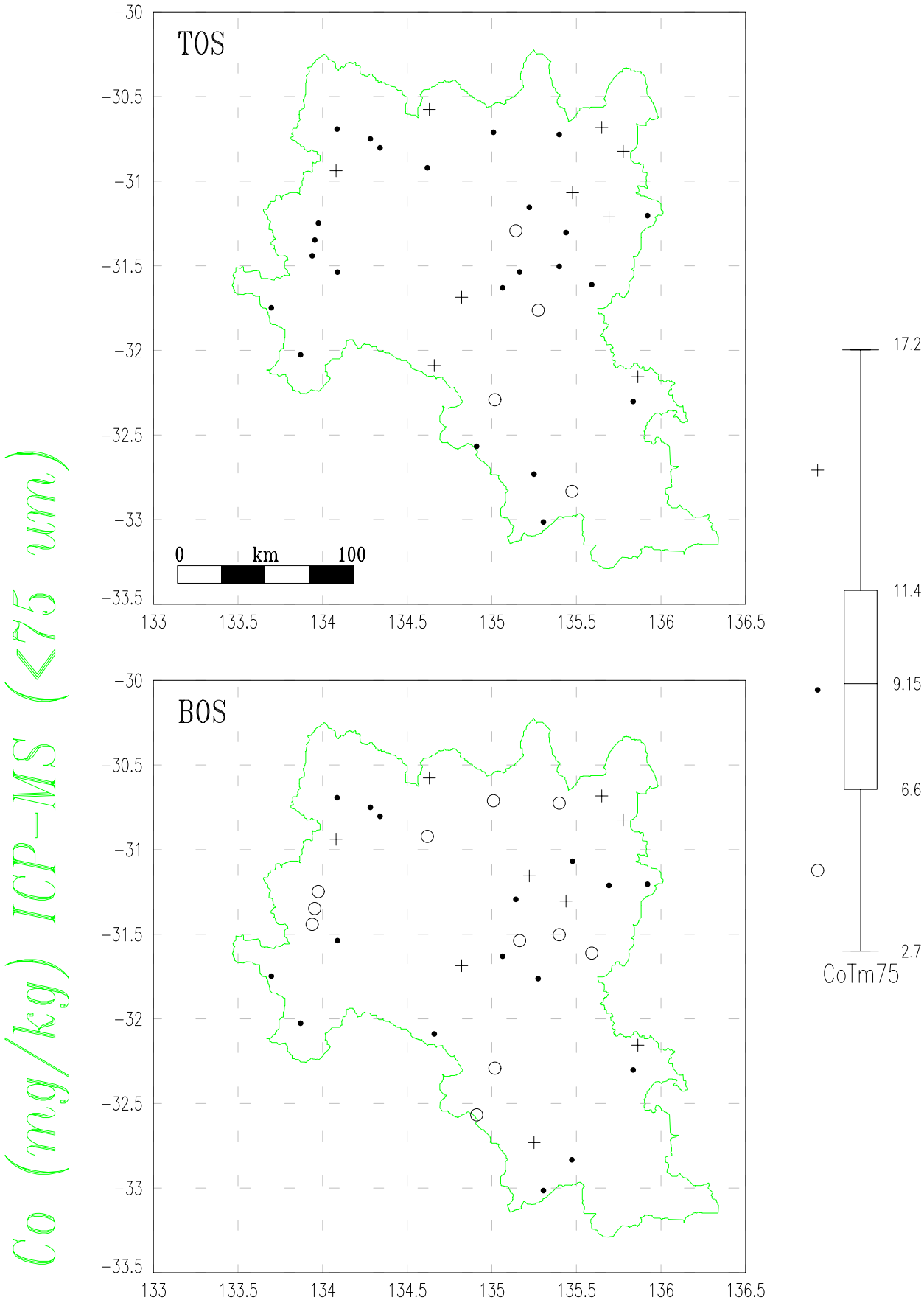
GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



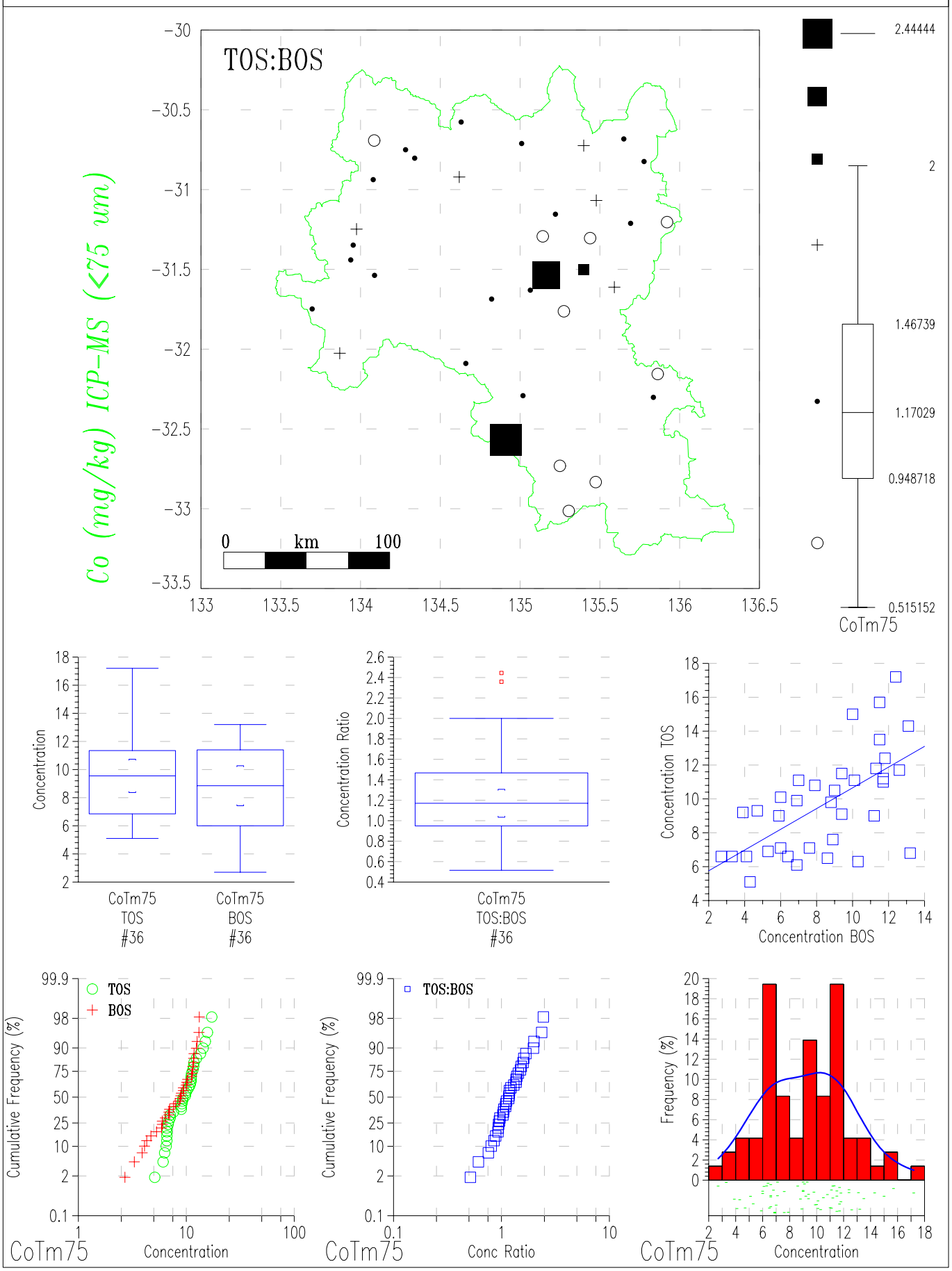
GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



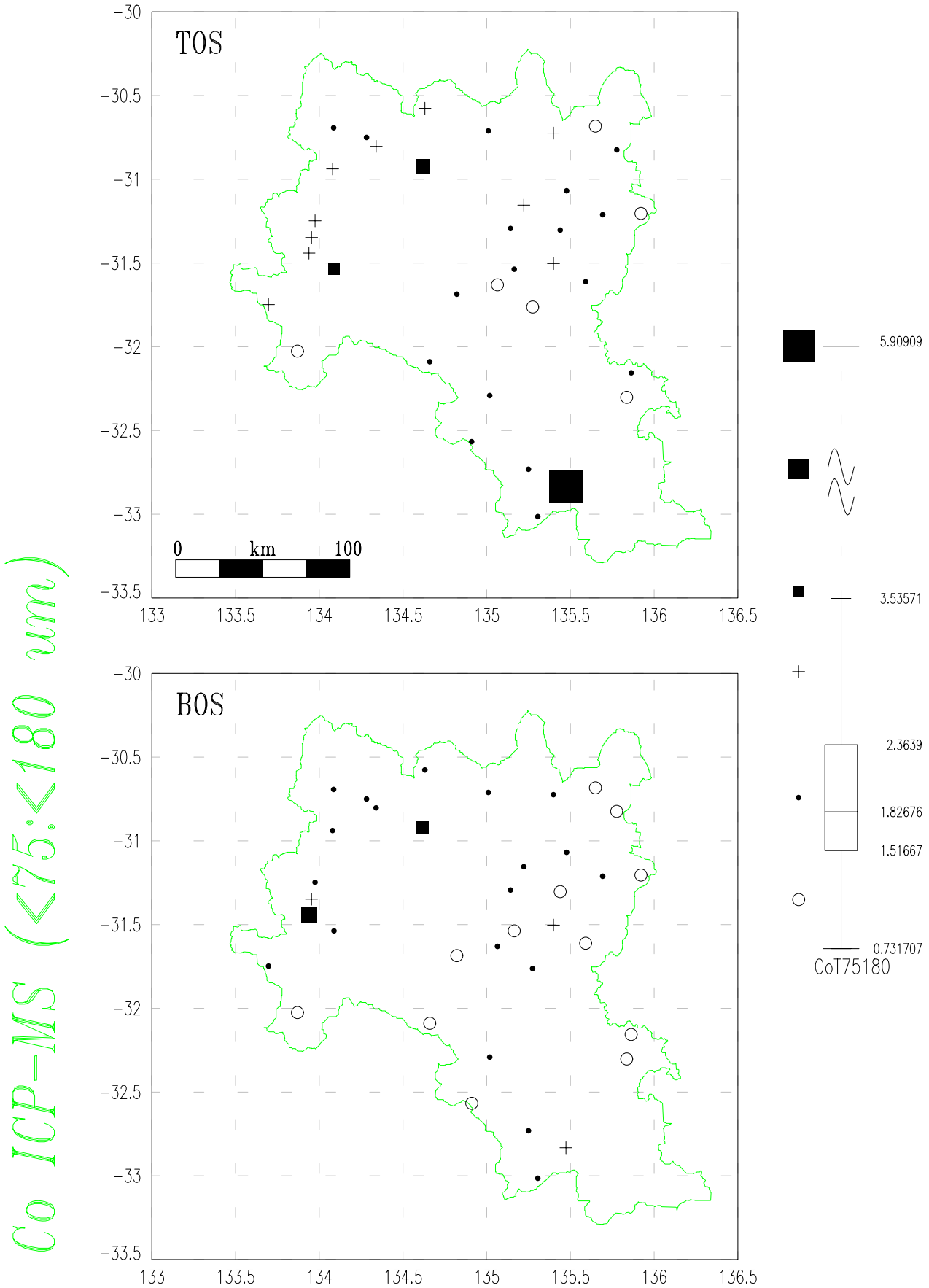
GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



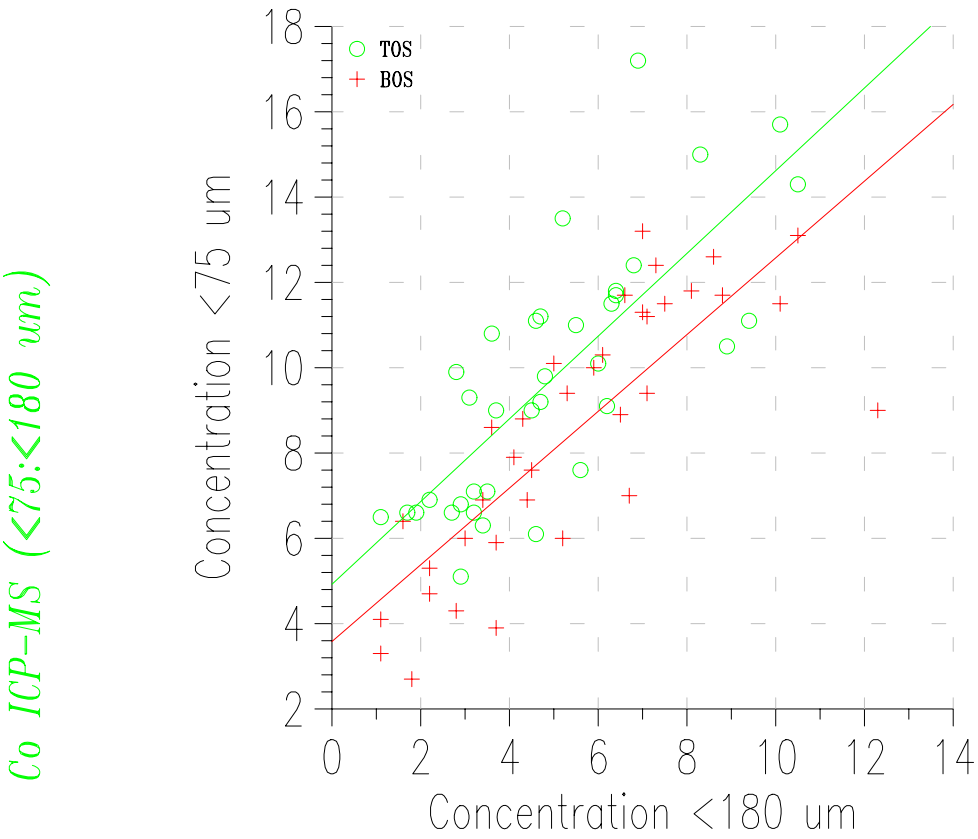
GAWLER GEOCHEMICAL SURVEY

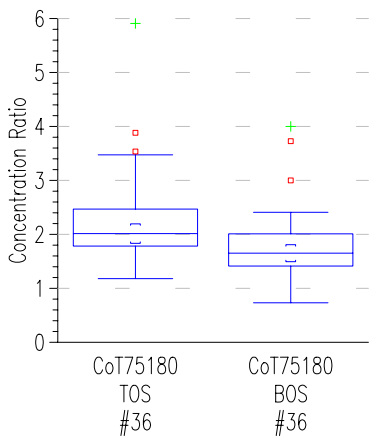
Top & Bottom Outlet Sediments (TOS & BOS)

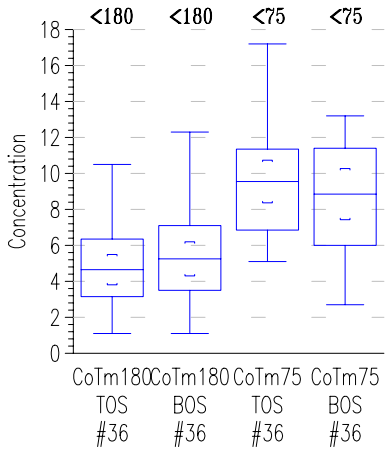


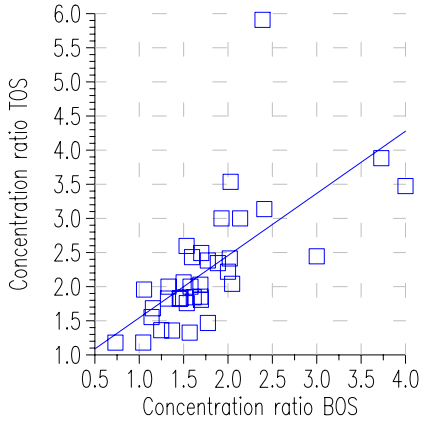
GAWLER GEOCHEMICAL SURVEY

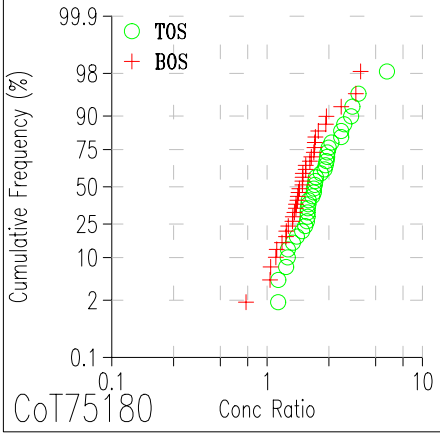
Top & Bottom Outlet Sediments (TOS & BOS)

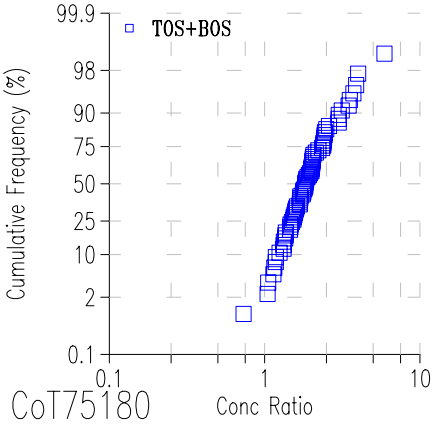


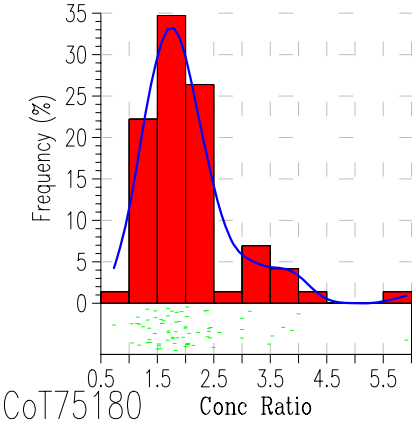






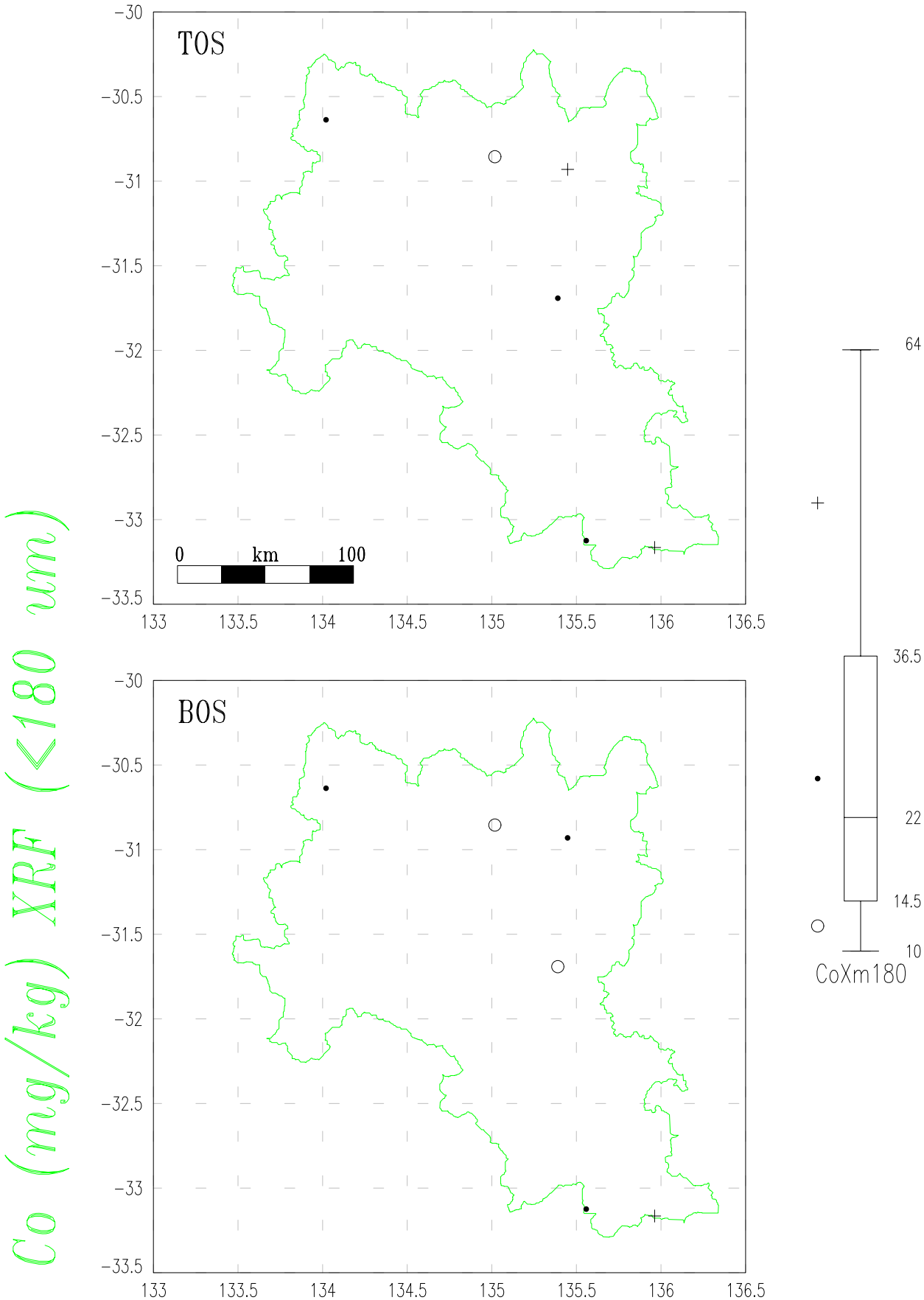






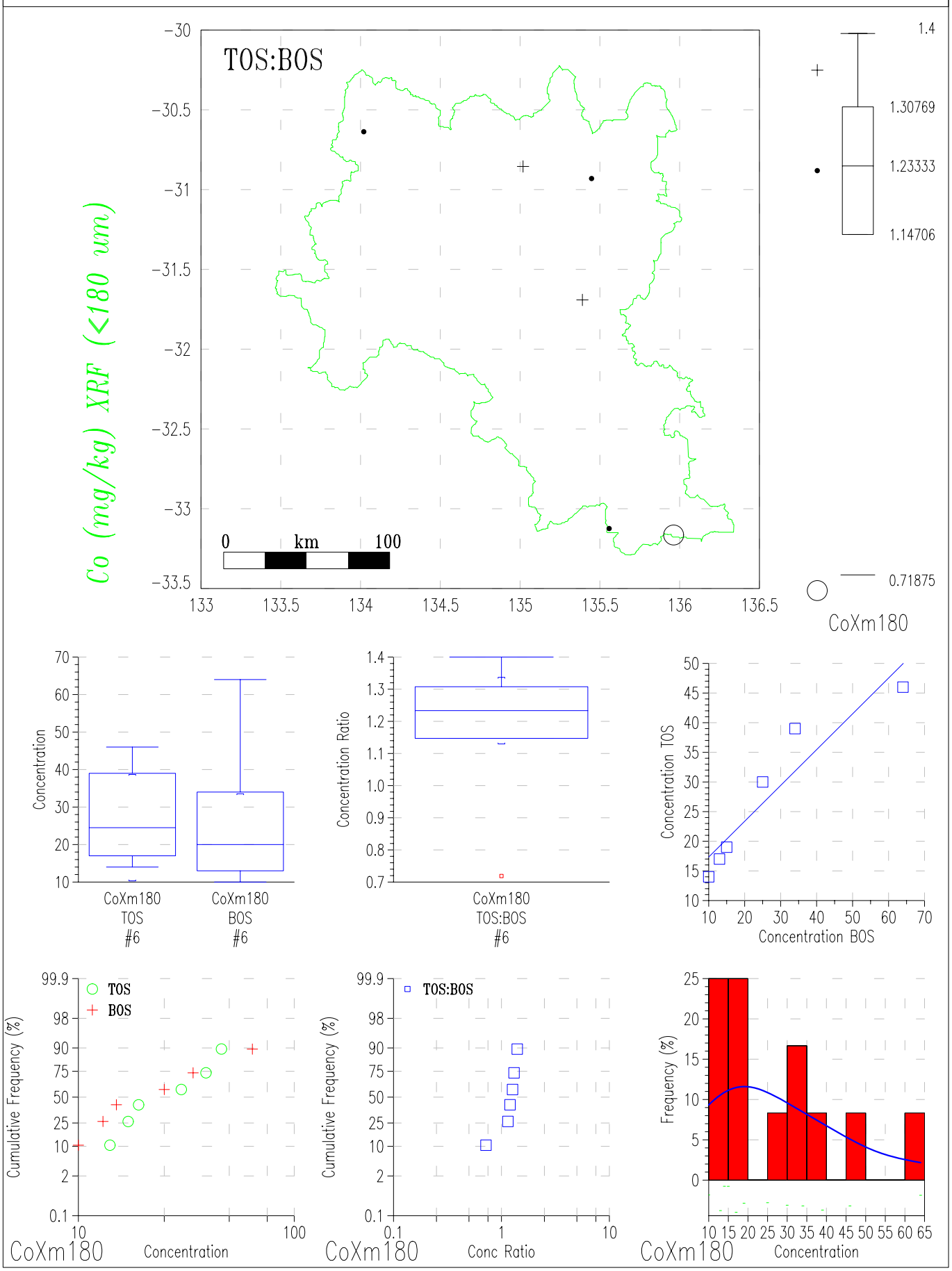
GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



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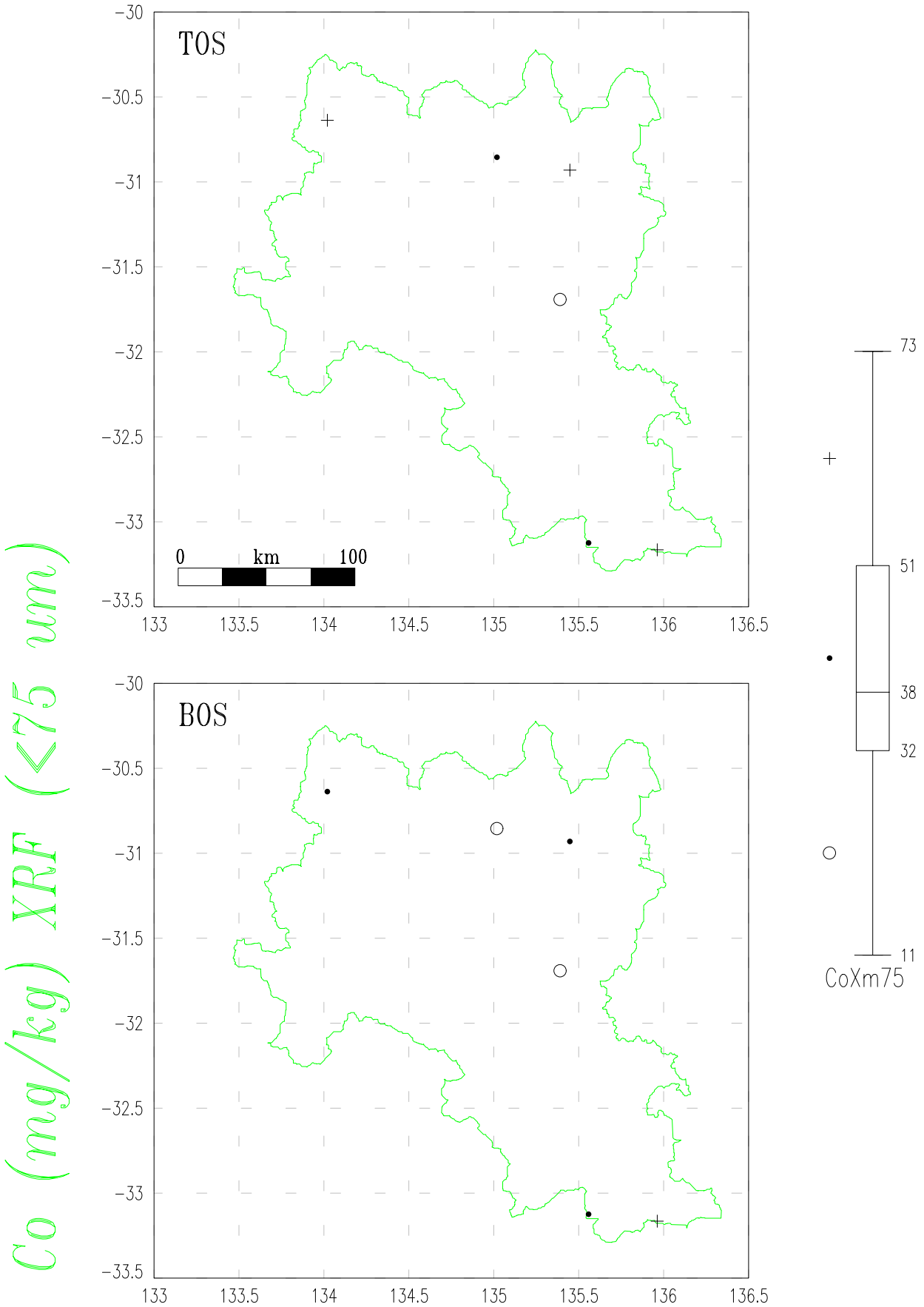
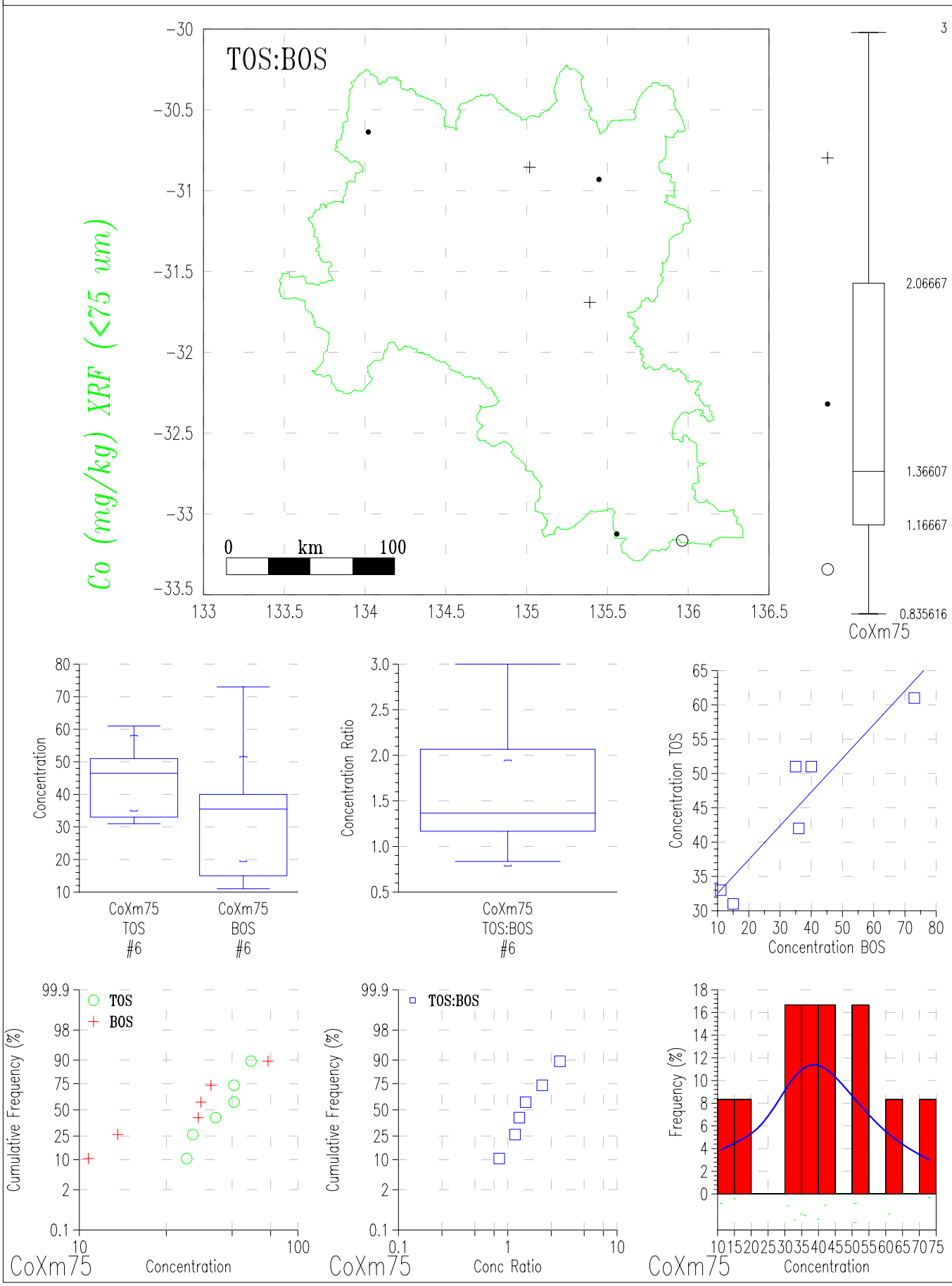
Top & Bottom Outlet Sediments (TOS & BOS)



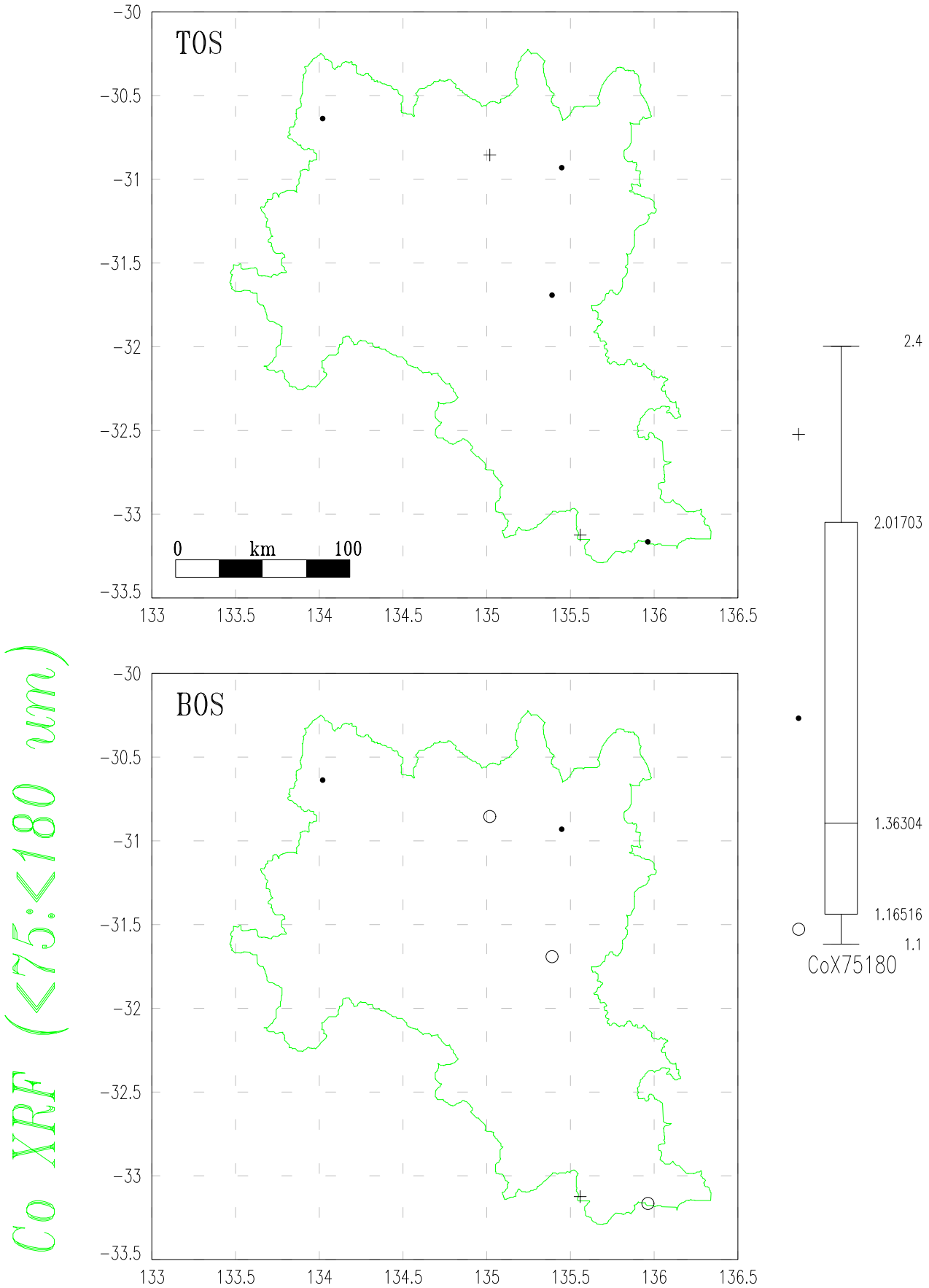
GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



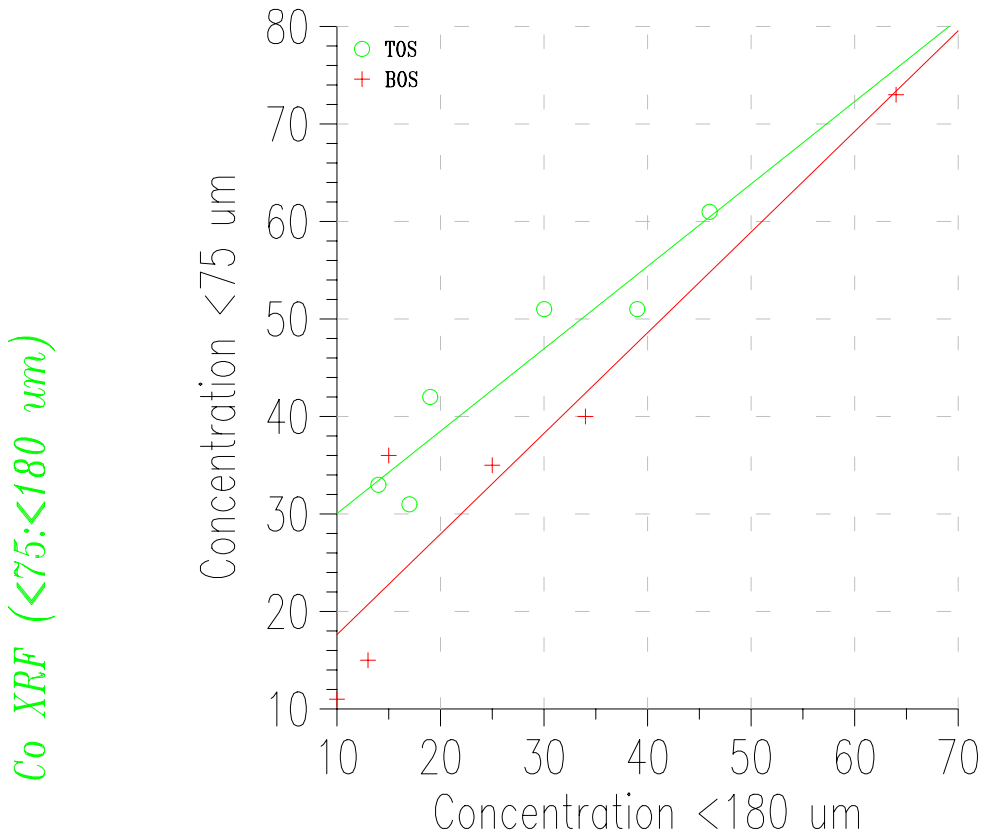
GAWLER GEOCHEMICAL SURVEY

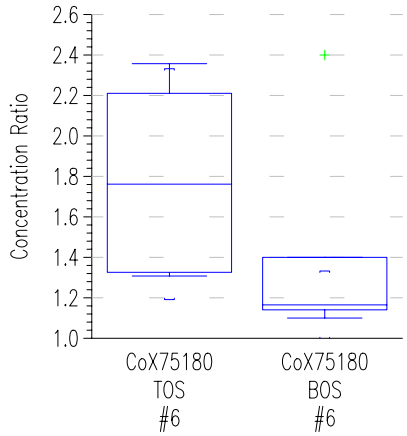
Top & Bottom Outlet Sediments (TOS & BOS)

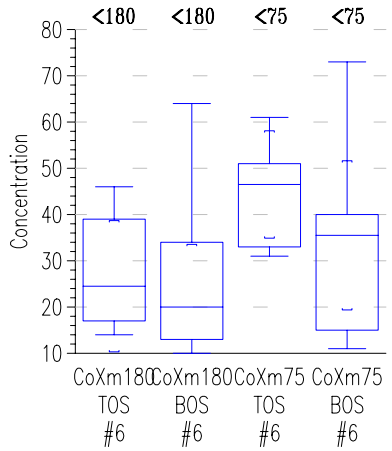


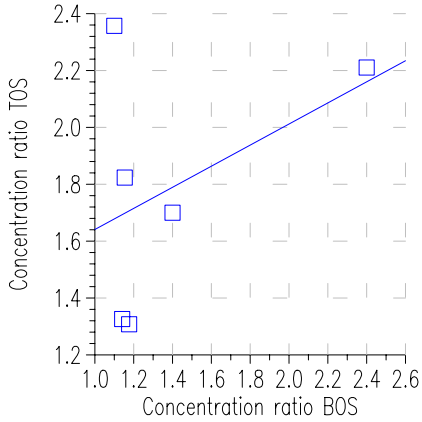
GAWLER GEOCHEMICAL SURVEY

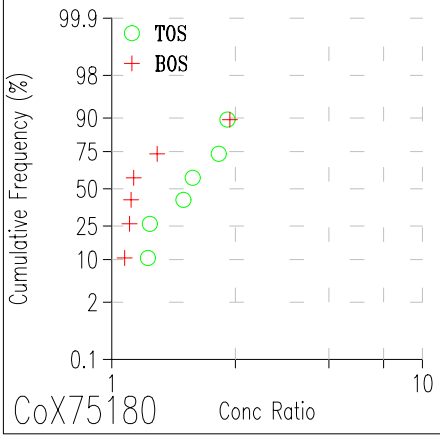
Top & Bottom Outlet Sediments (TOS & BOS)

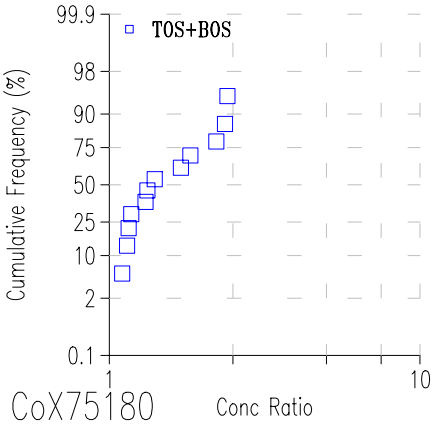


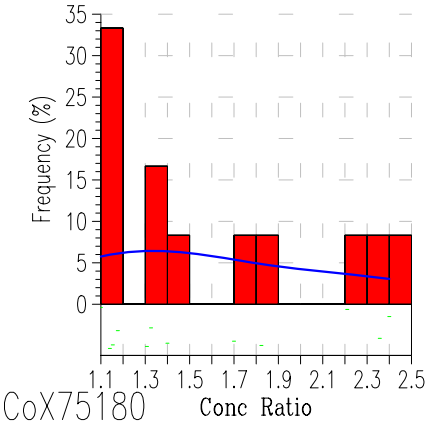






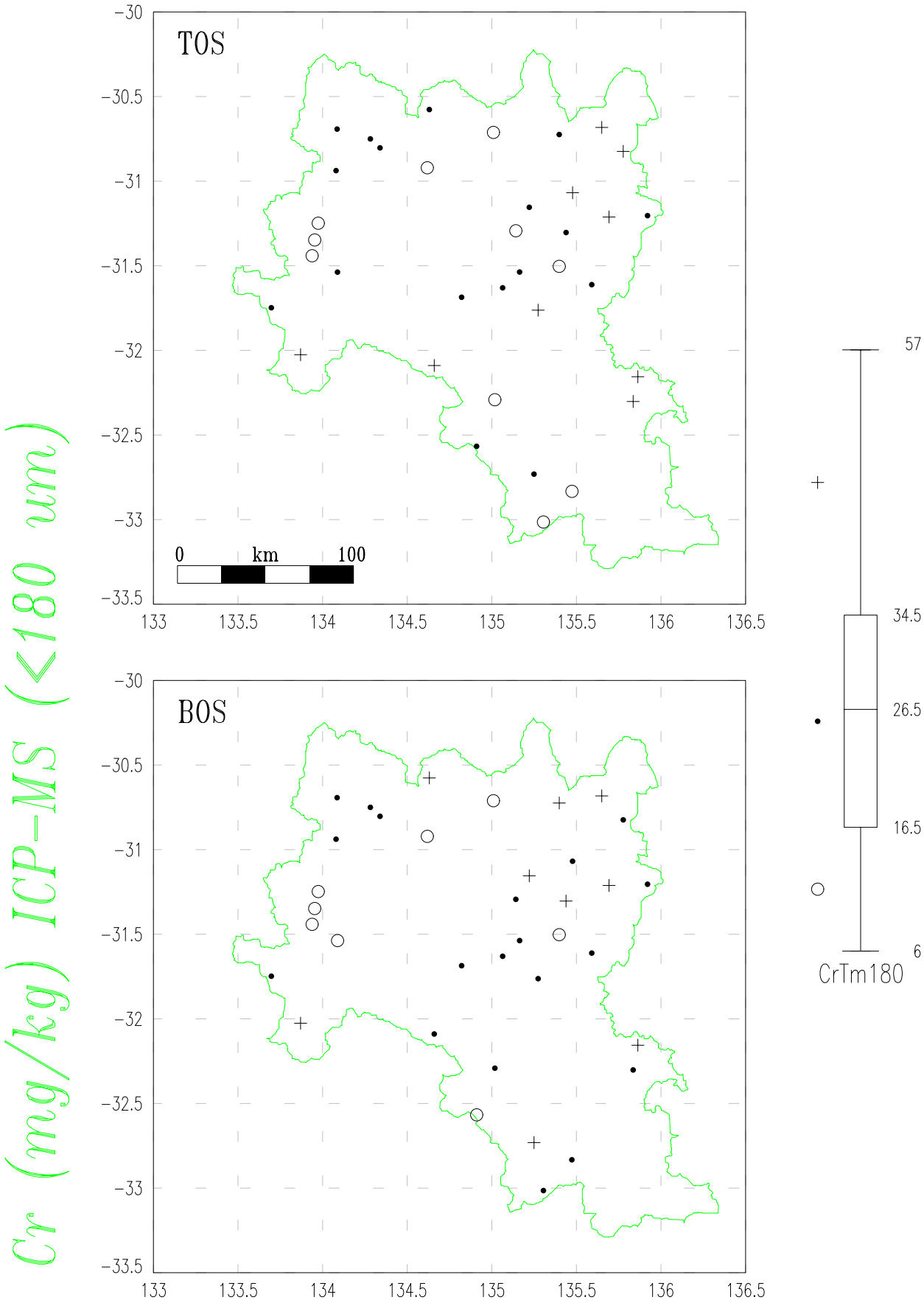






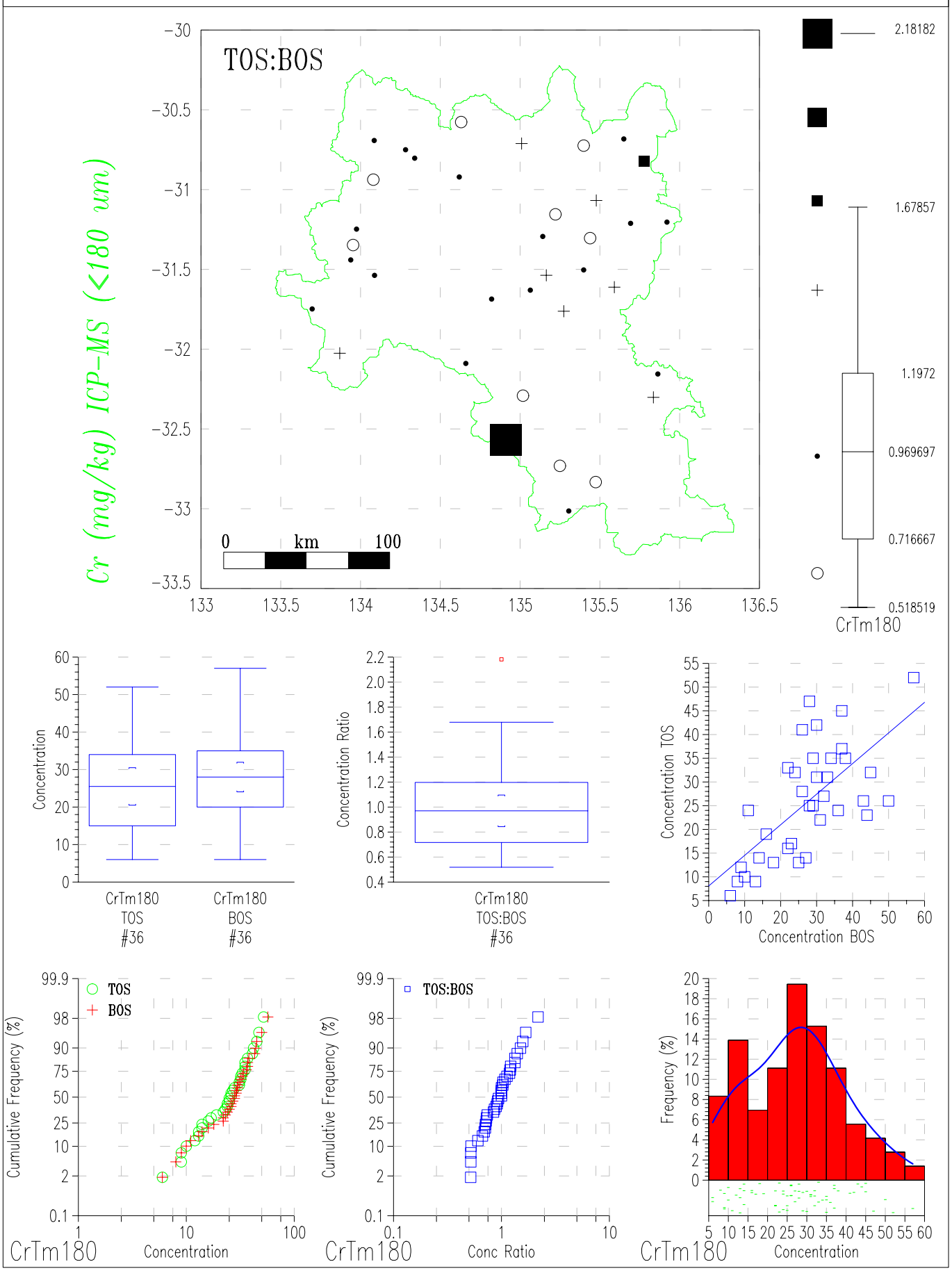
GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



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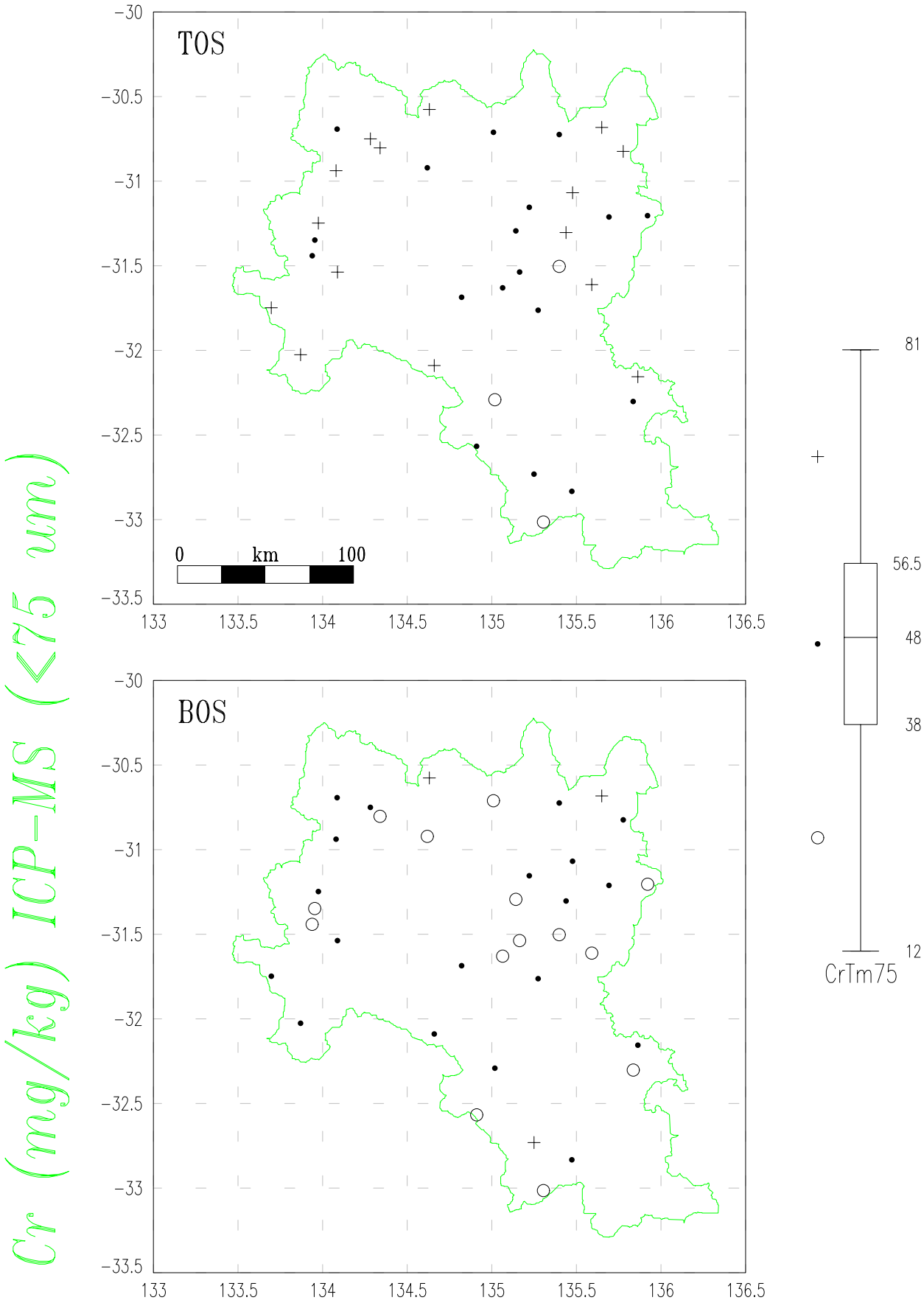
Top & Bottom Outlet Sediments (TOS & BOS)



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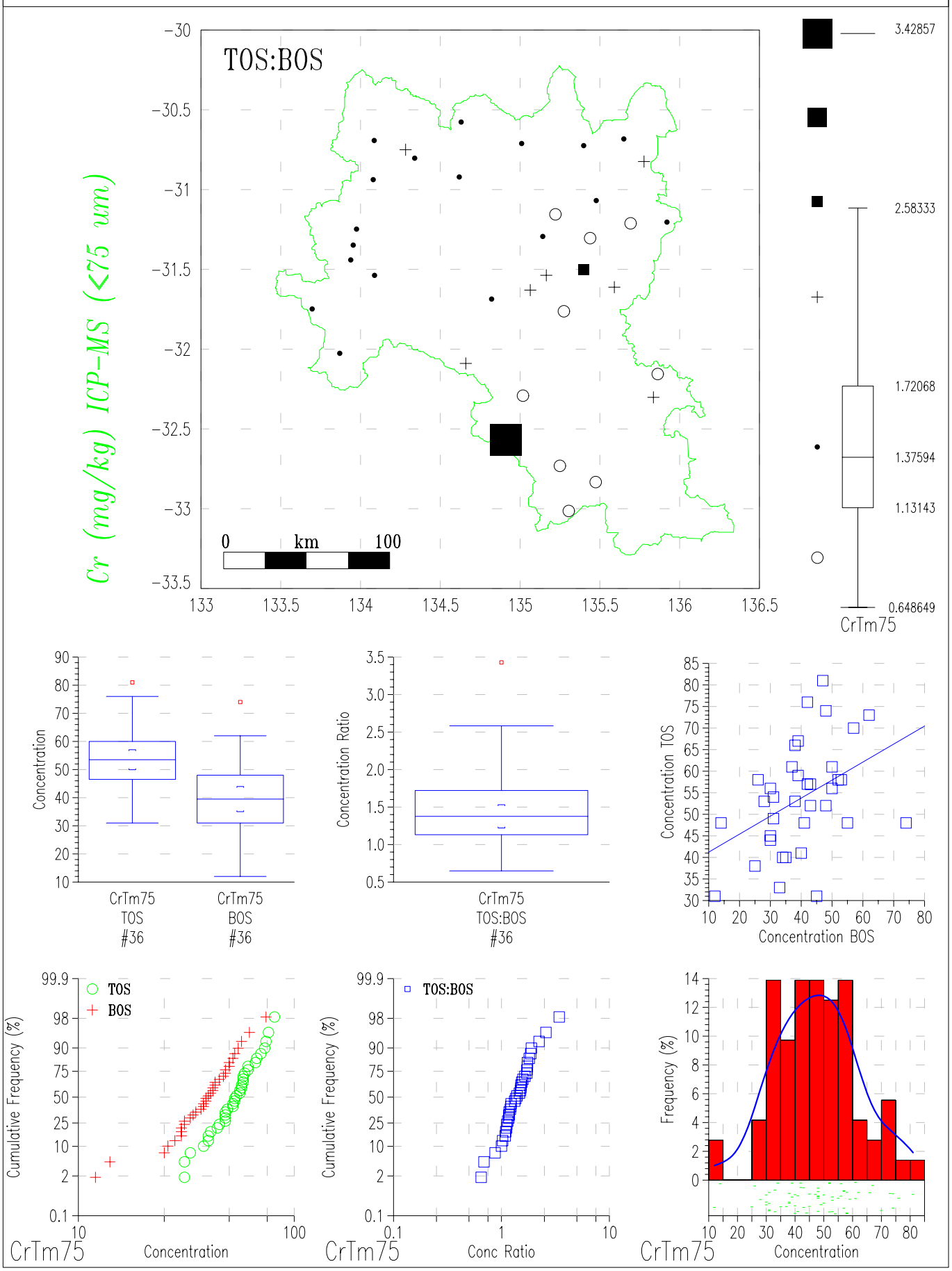
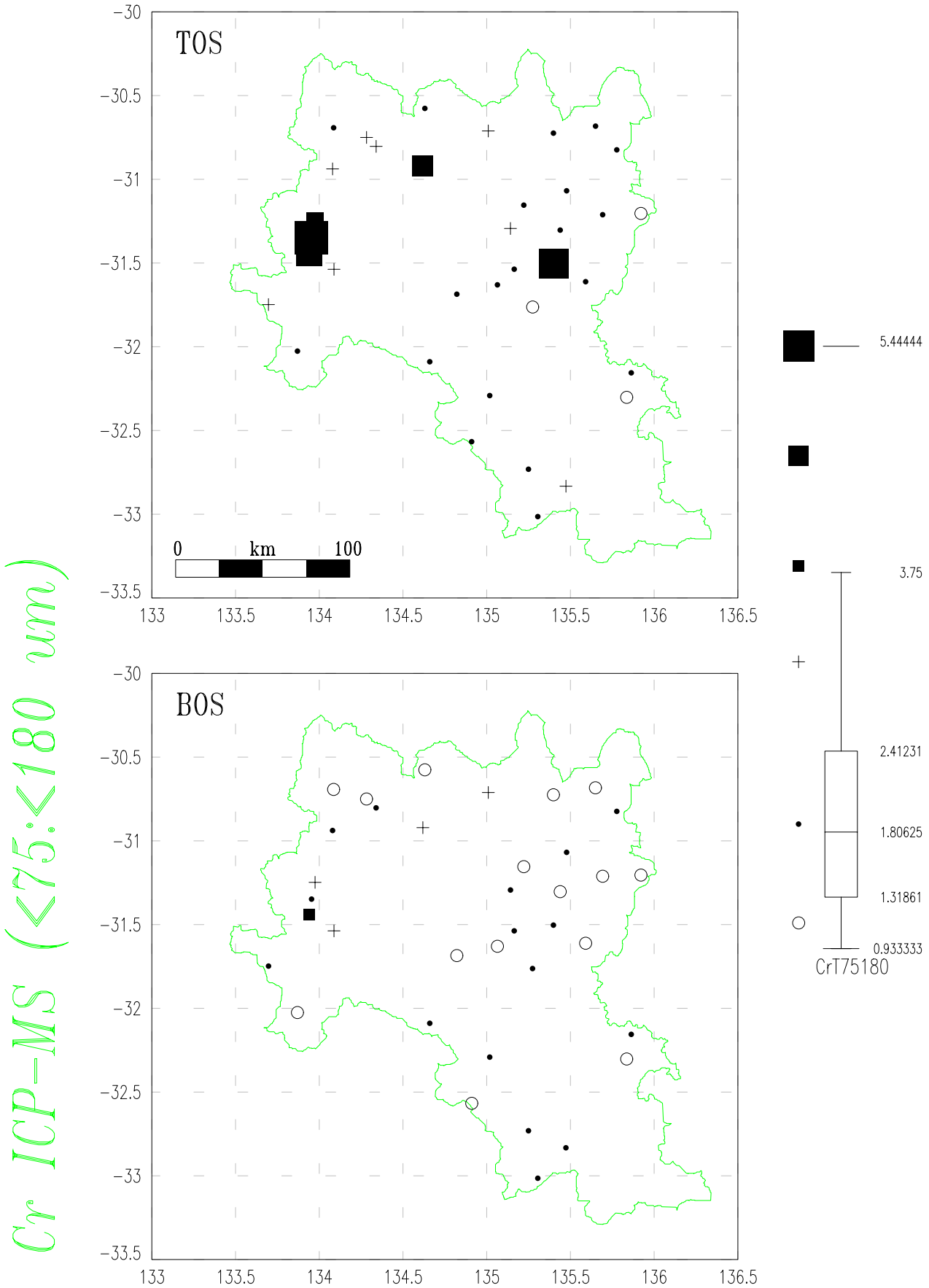
Top & Bottom Outlet Sediments (TOS & BOS)



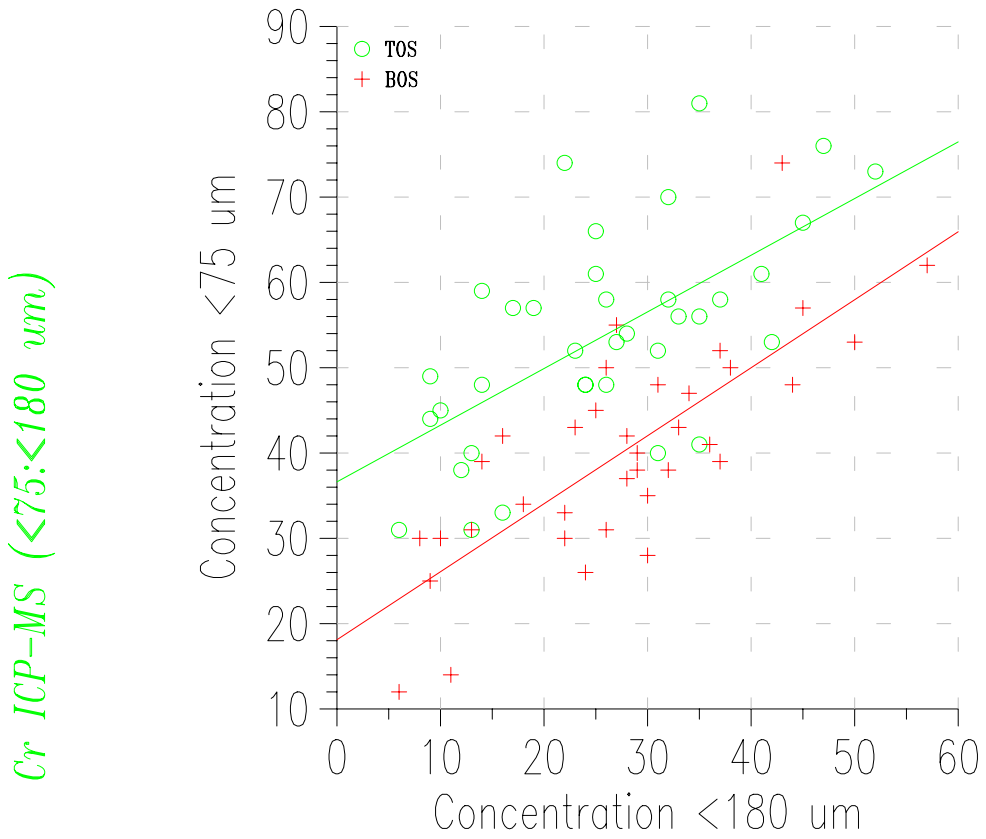
GAWLER GEOCHEMICAL SURVEY

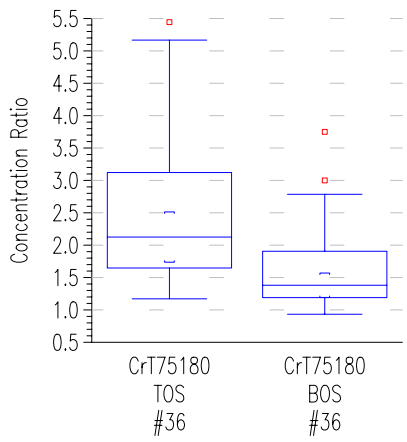
Top & Bottom Outlet Sediments (TOS & BOS)

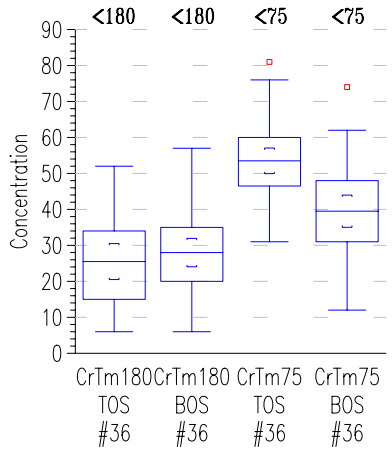


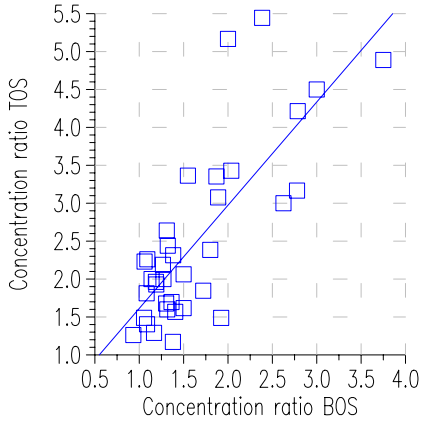
GAWLER GEOCHEMICAL SURVEY

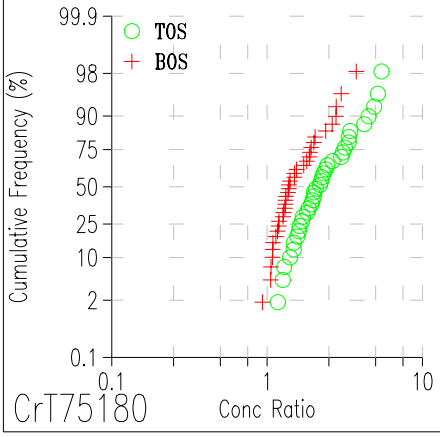
Top & Bottom Outlet Sediments (TOS & BOS)

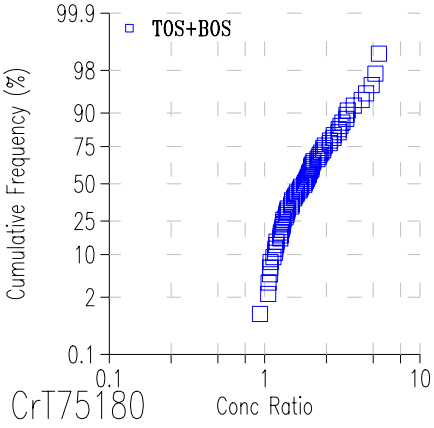


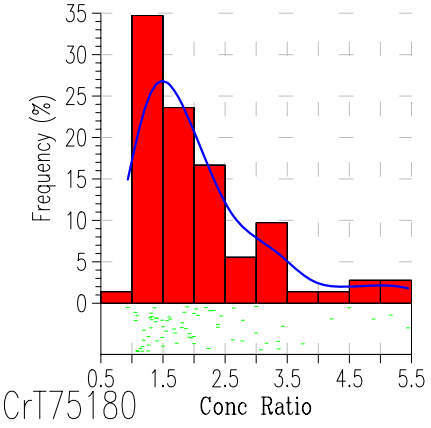








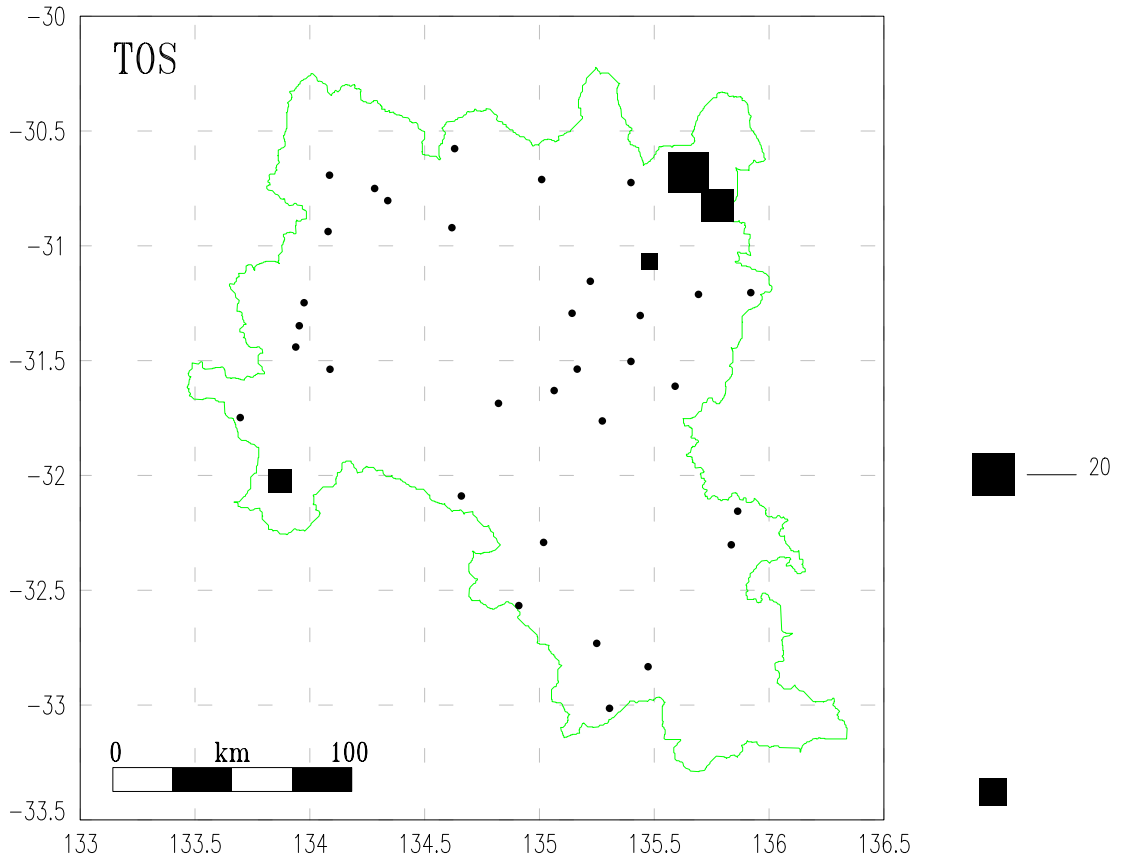


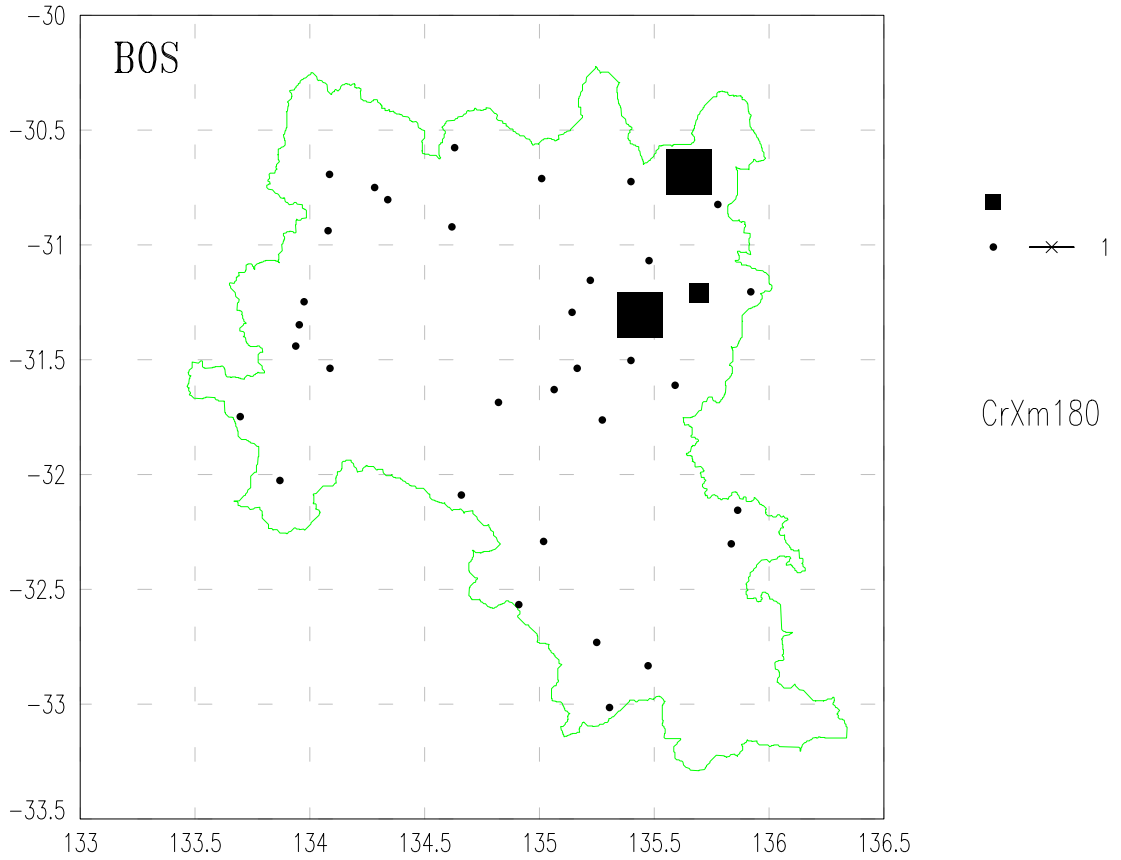


GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)

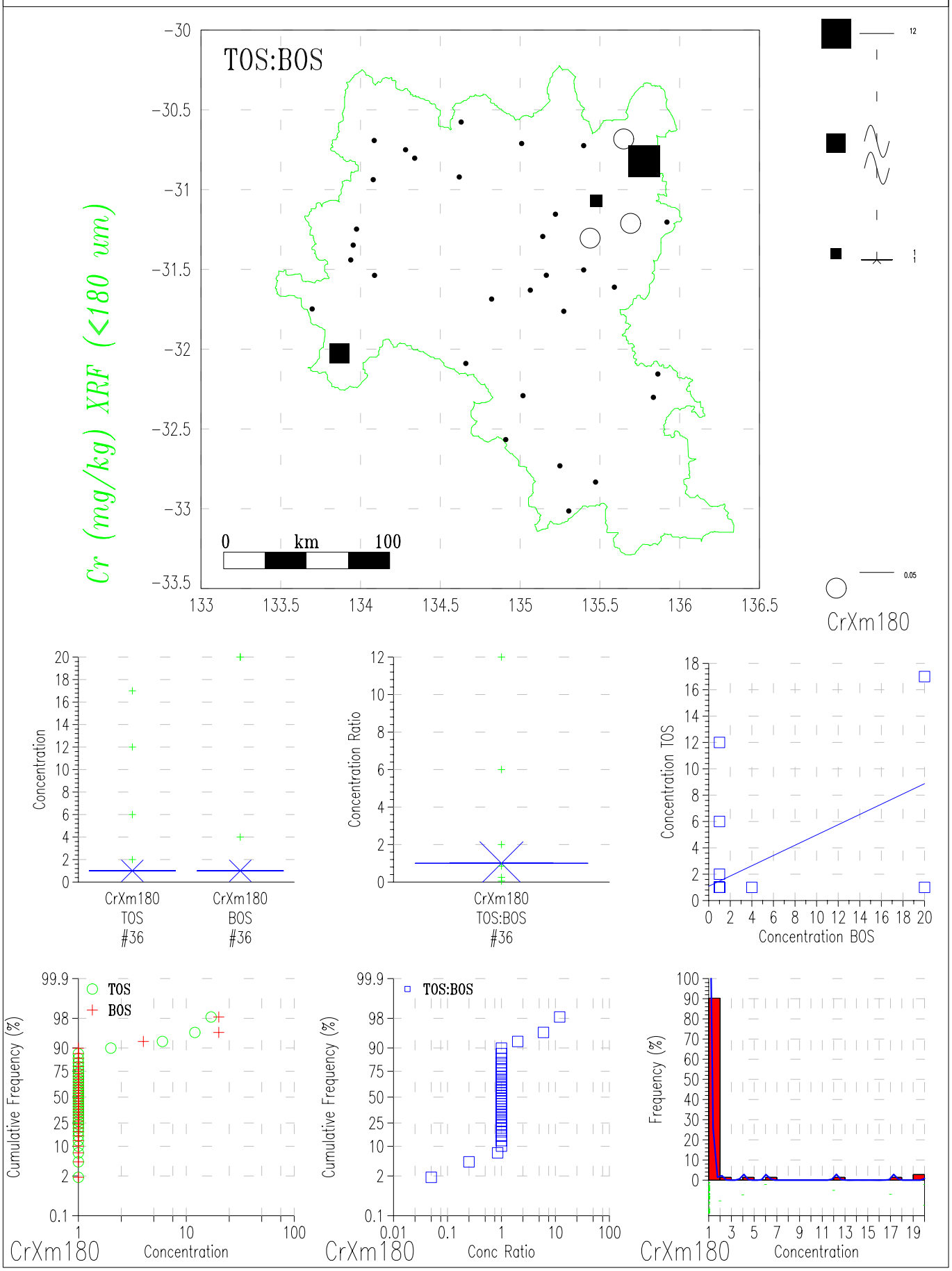
Cr (mg/kg) XRF (<180 um)





GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



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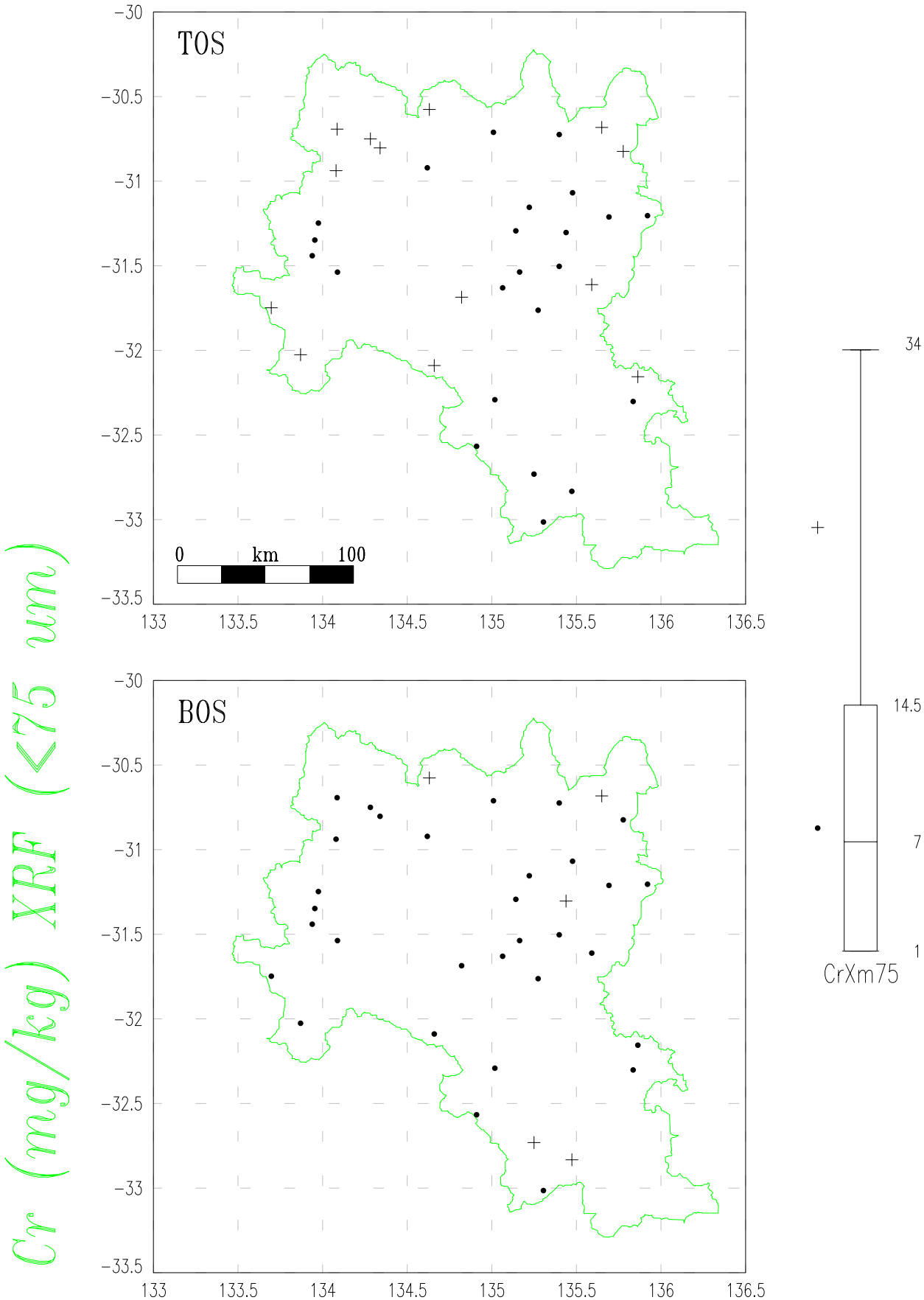
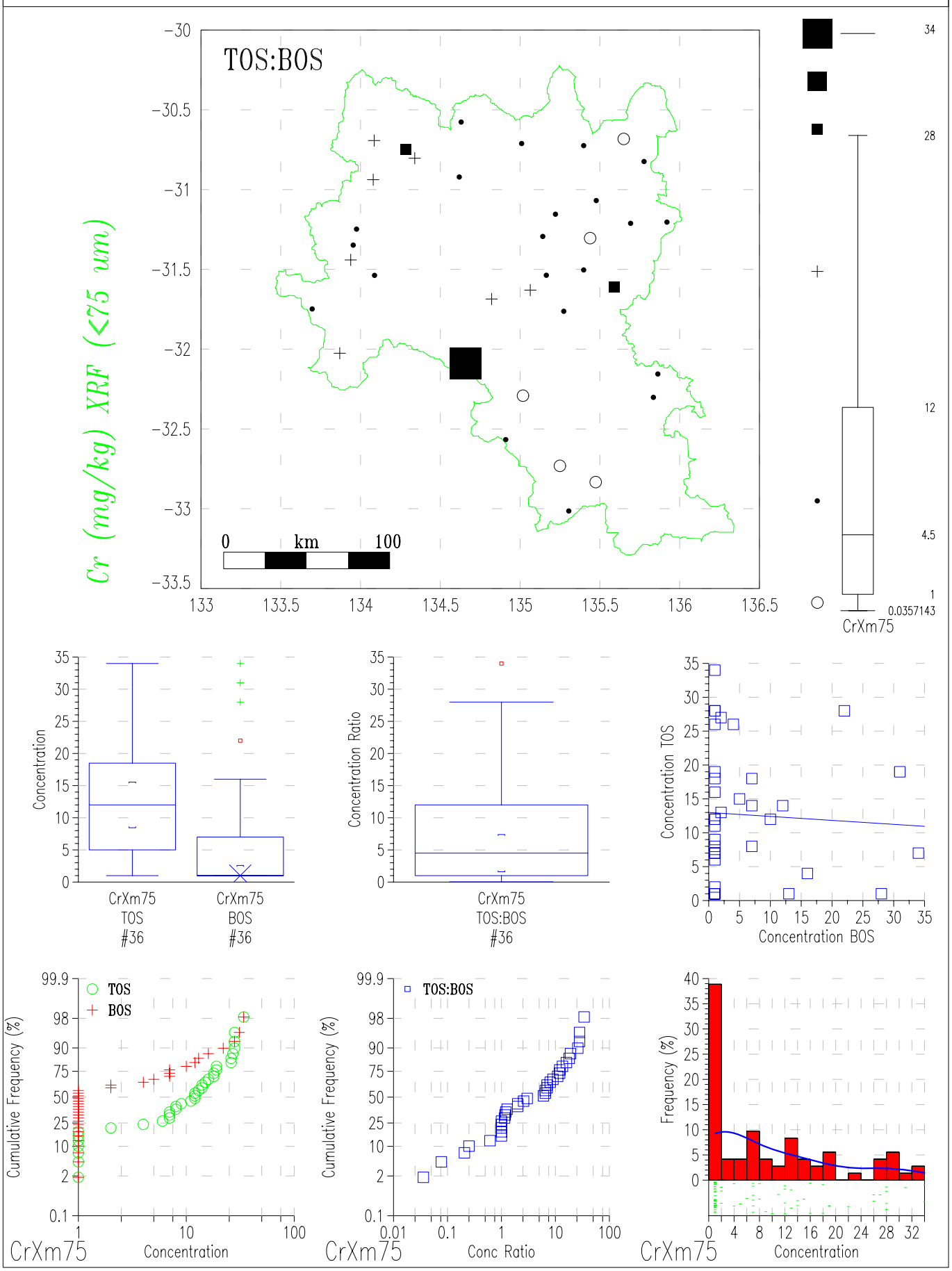
Top & Bottom Outlet Sediments (TOS & BOS)



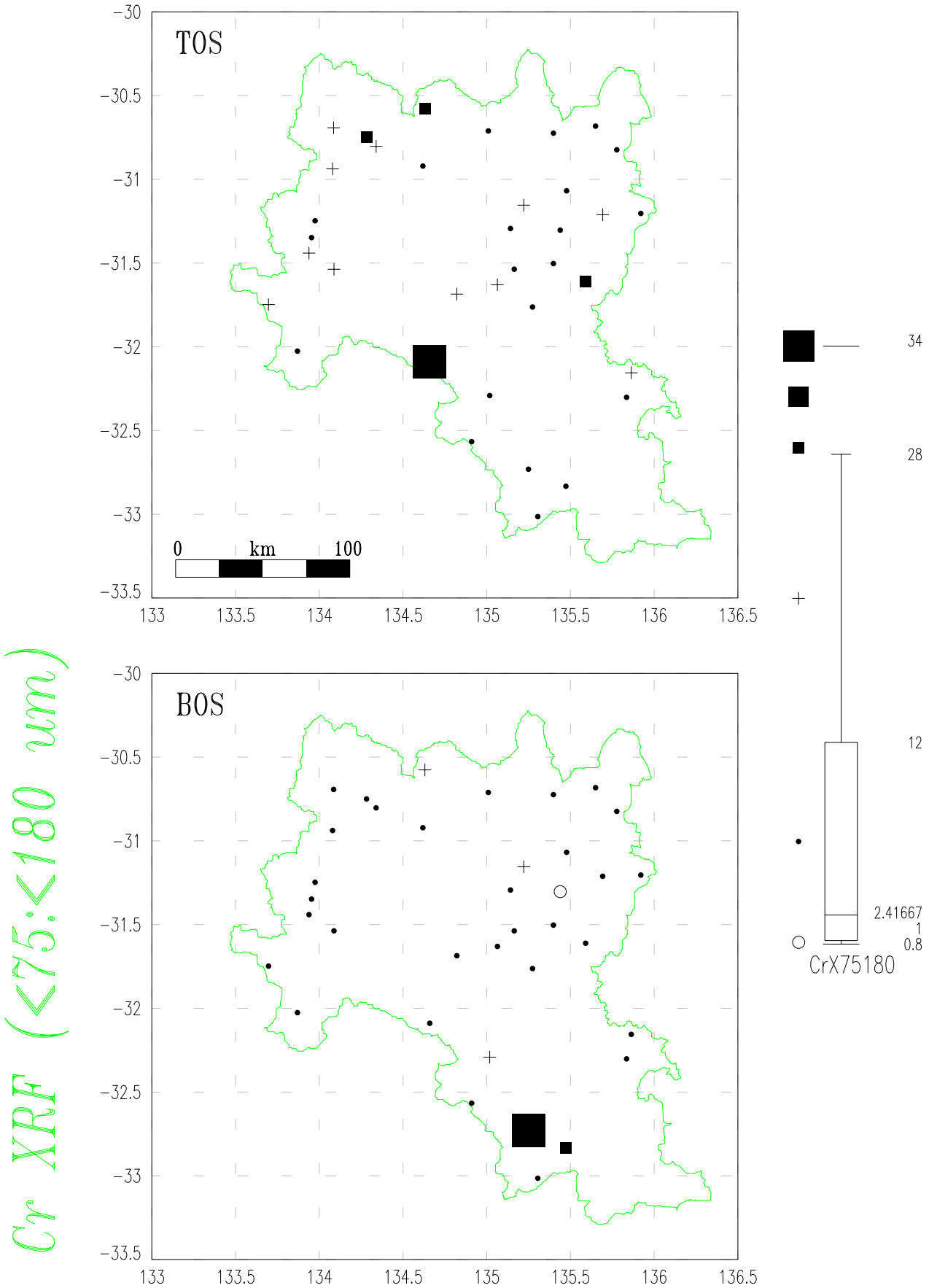
GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



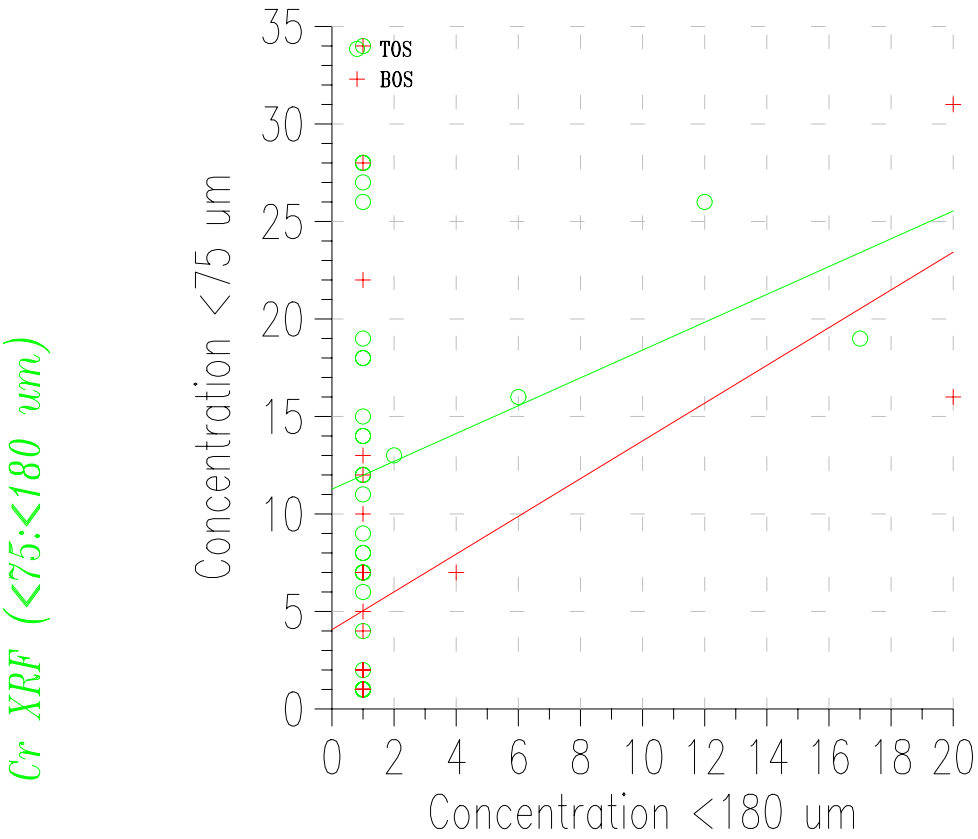
GAWLER GEOCHEMICAL SURVEY

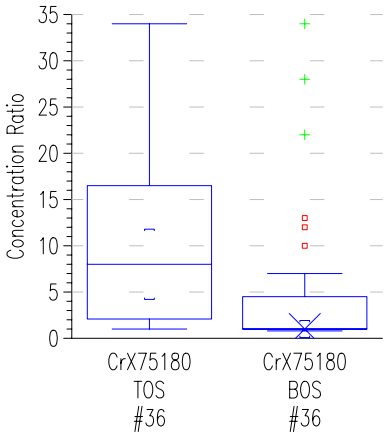
Top & Bottom Outlet Sediments (TOS & BOS)

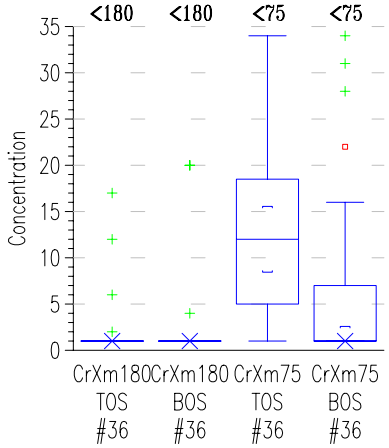


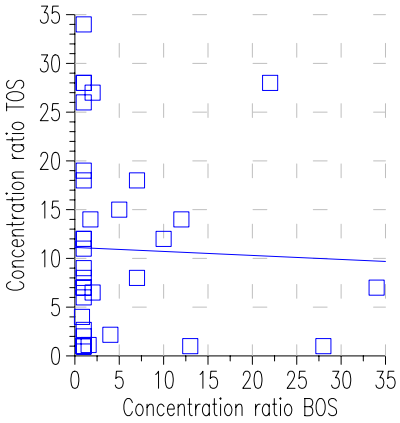
GAWLER GEOCHEMICAL SURVEY

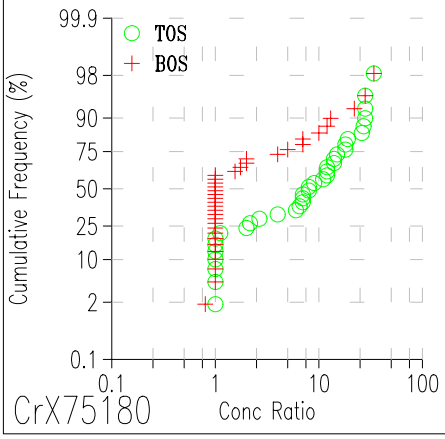
Top & Bottom Outlet Sediments (TOS & BOS)

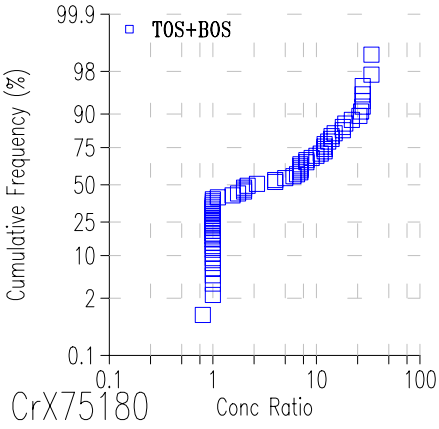


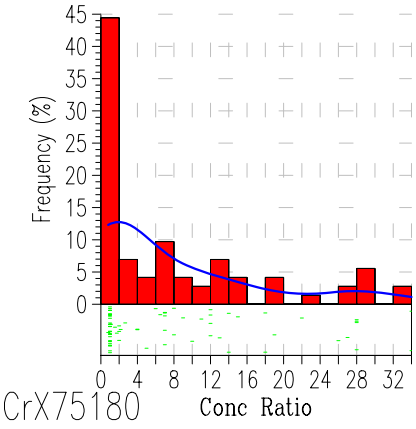






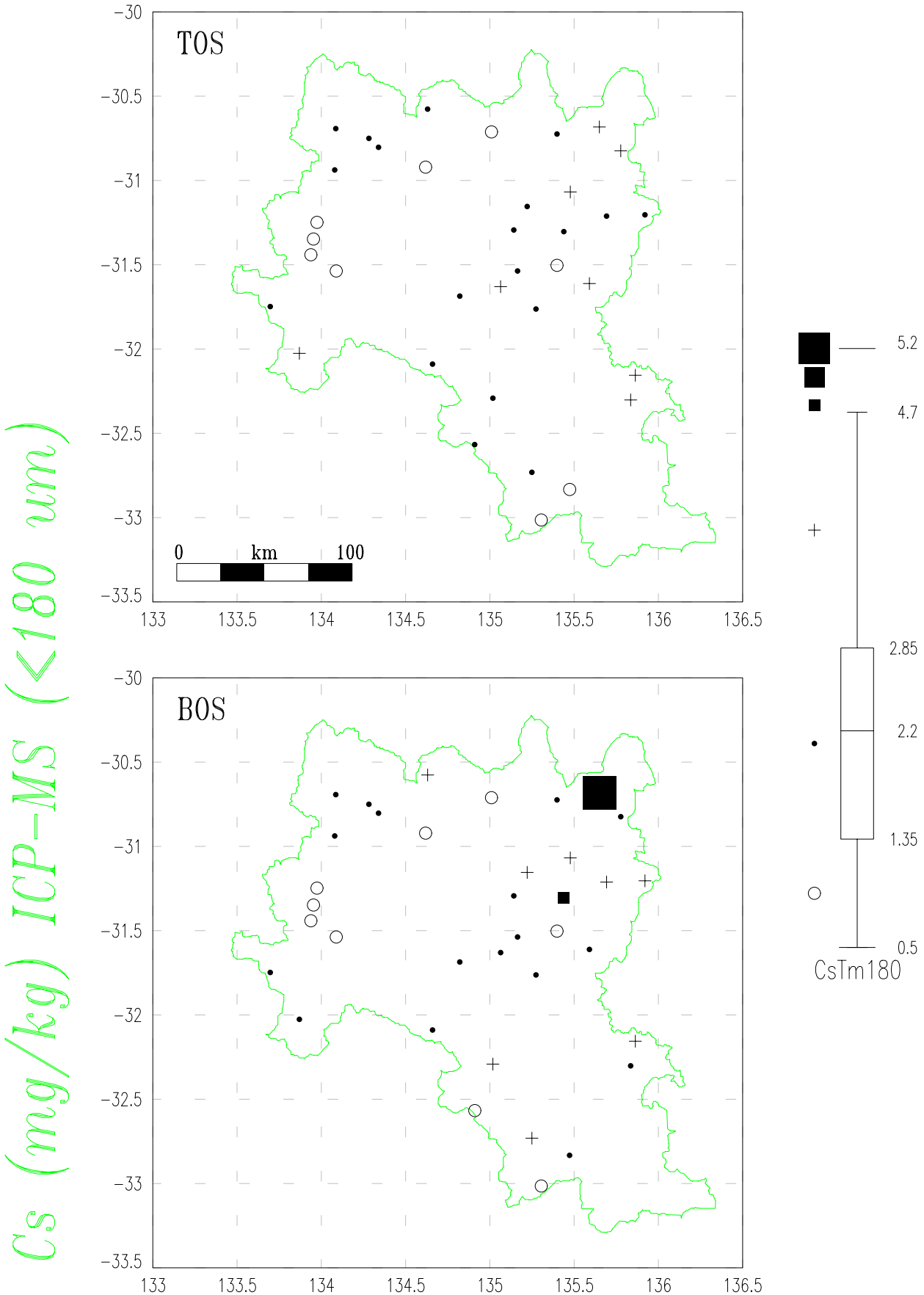






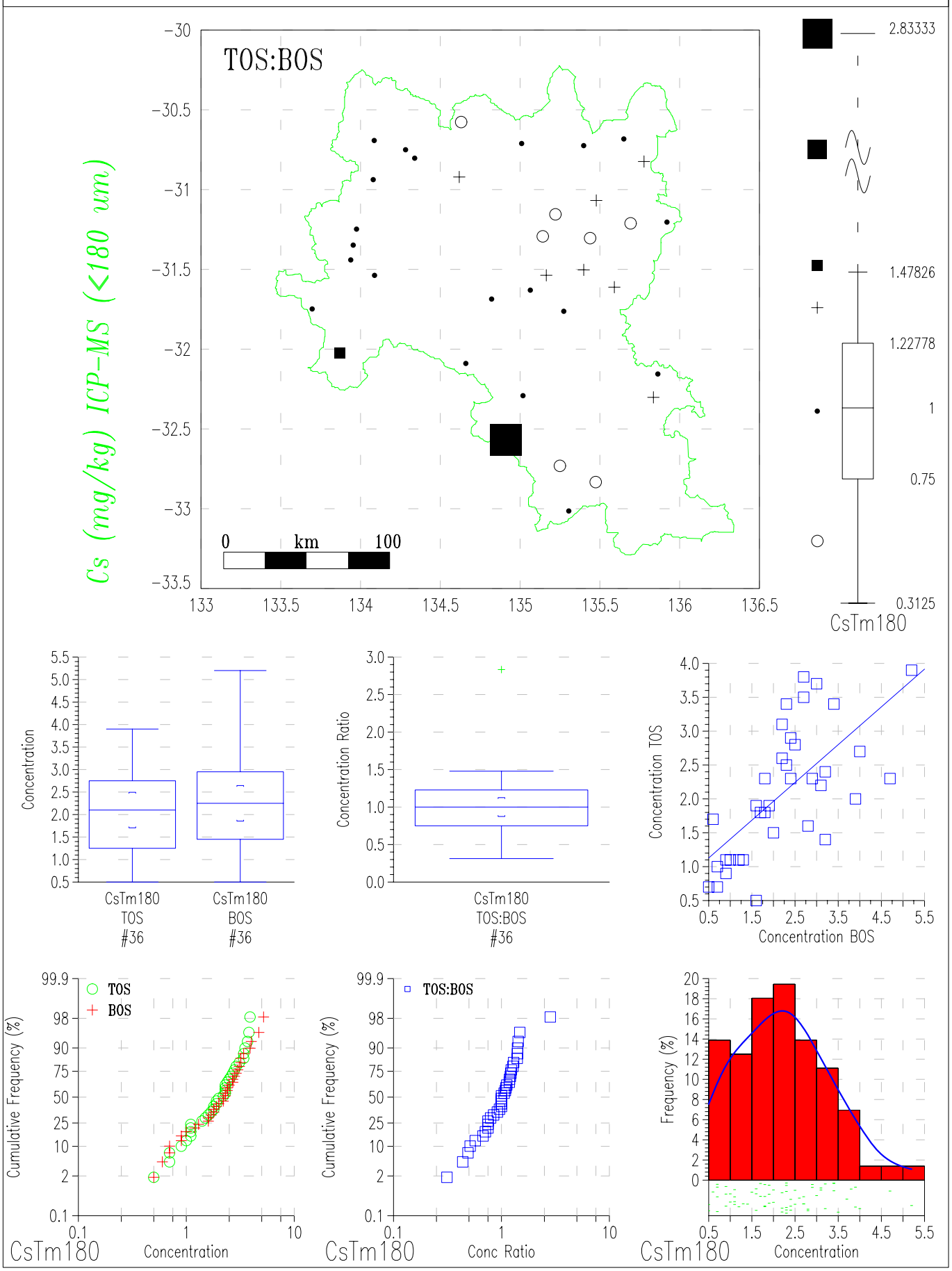
GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



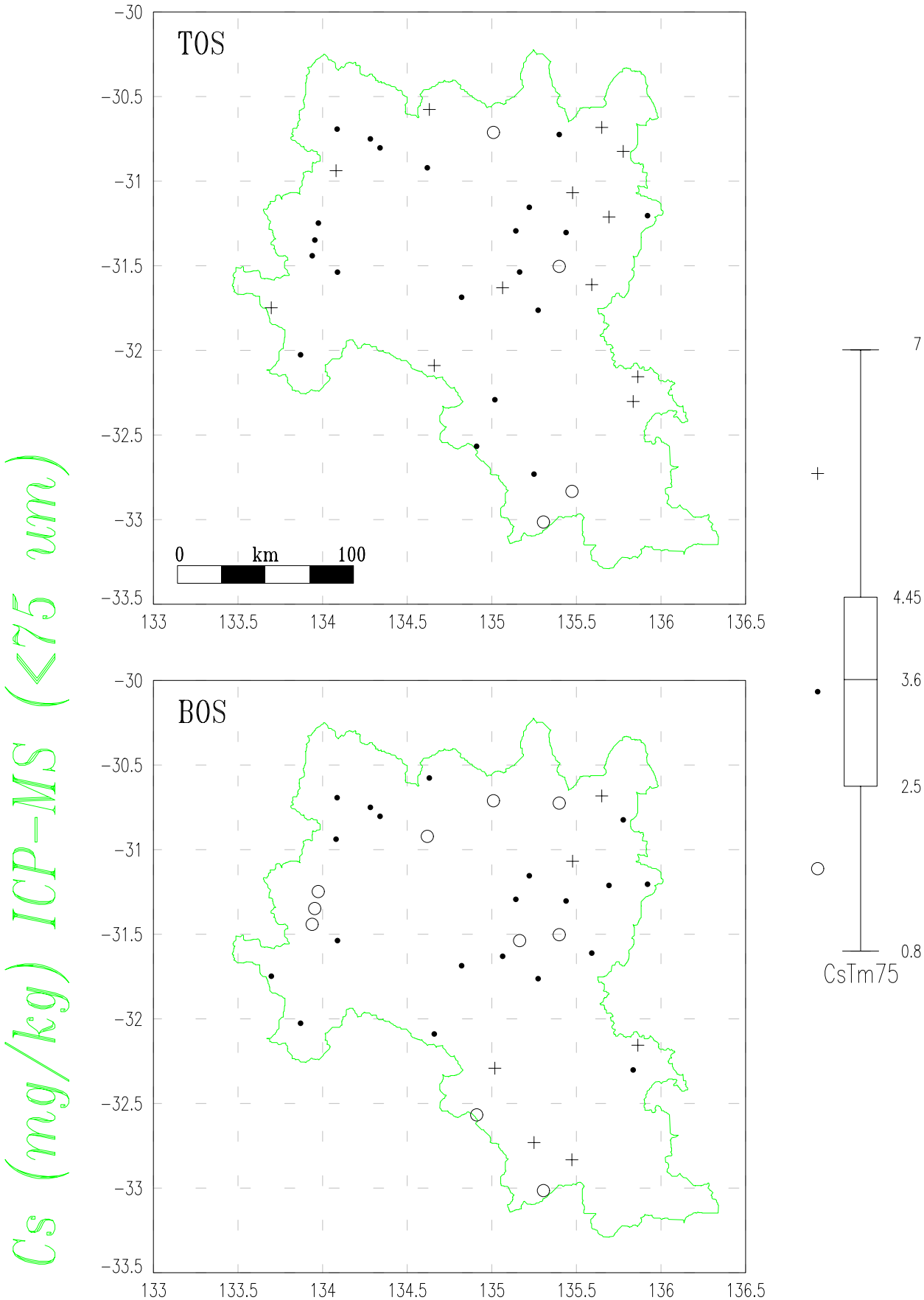
GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



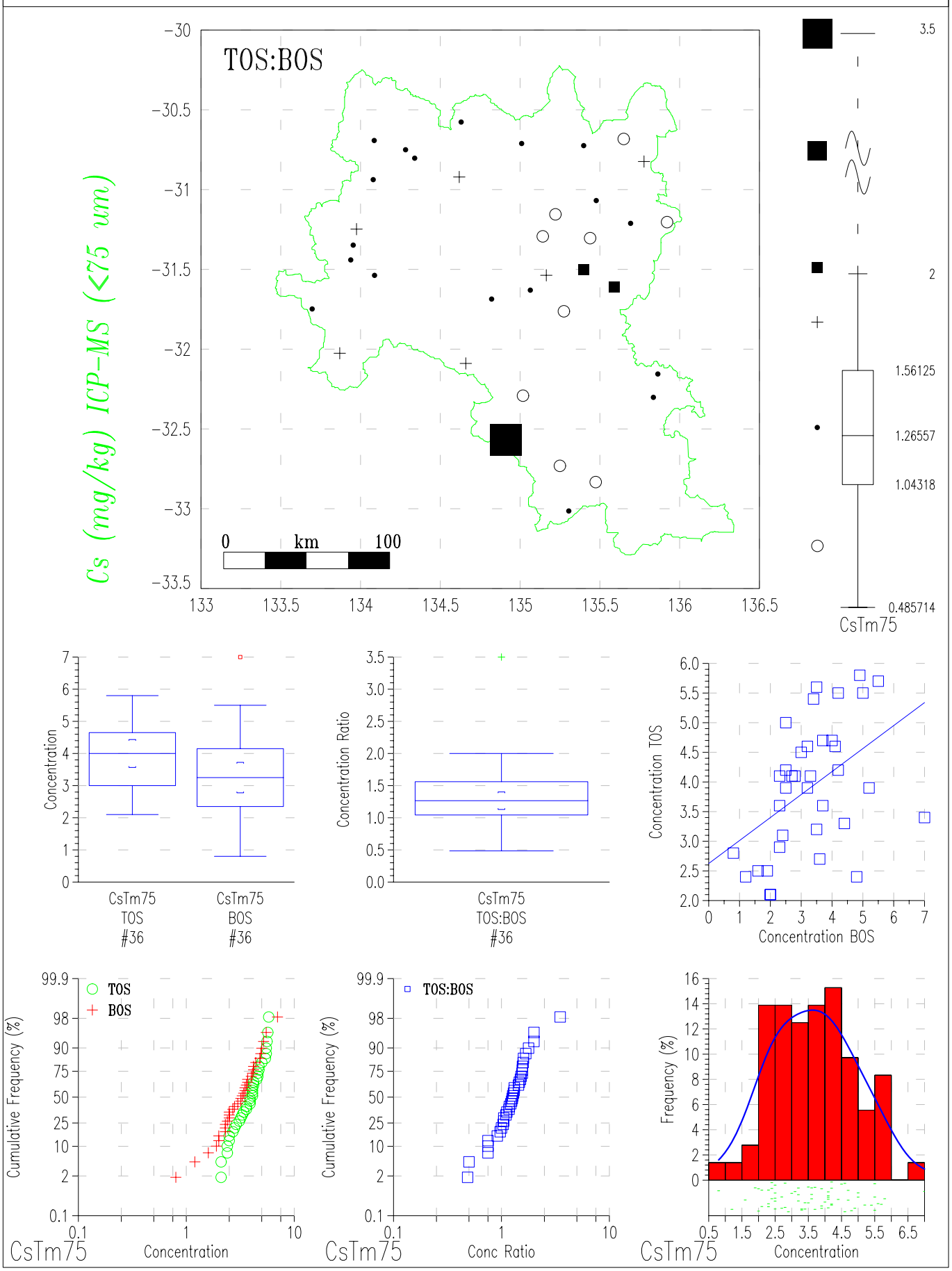
GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



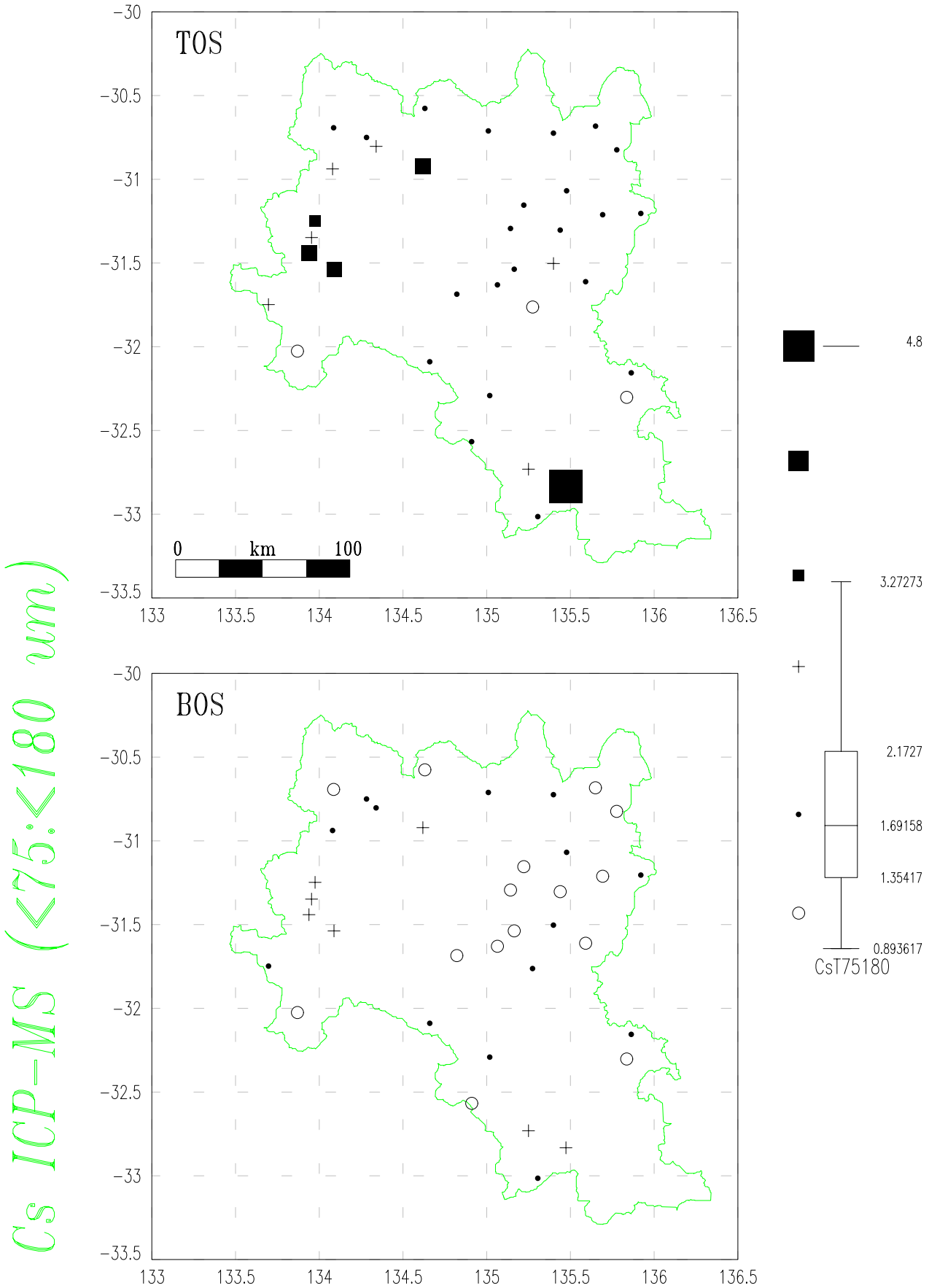
GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



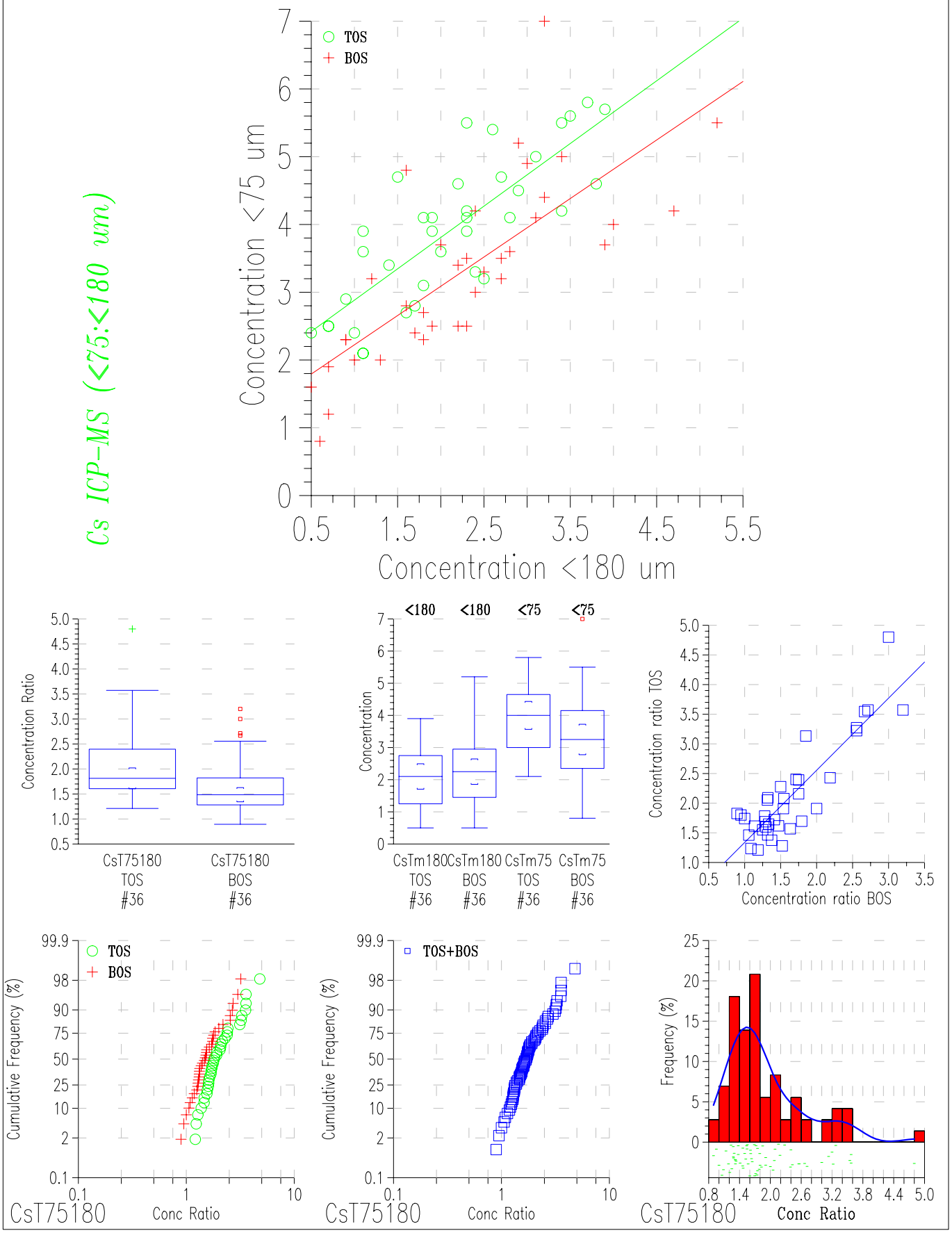
GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



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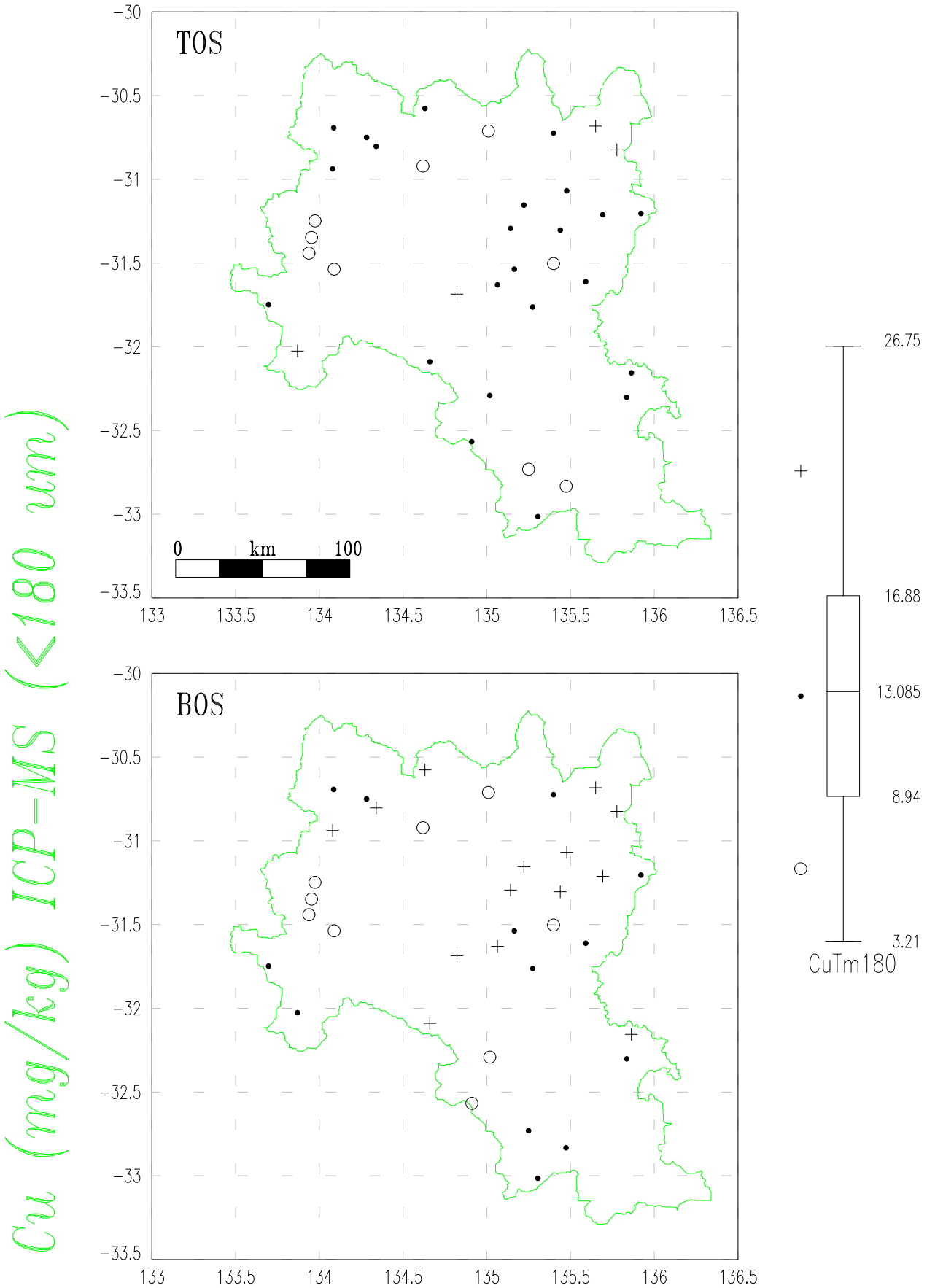
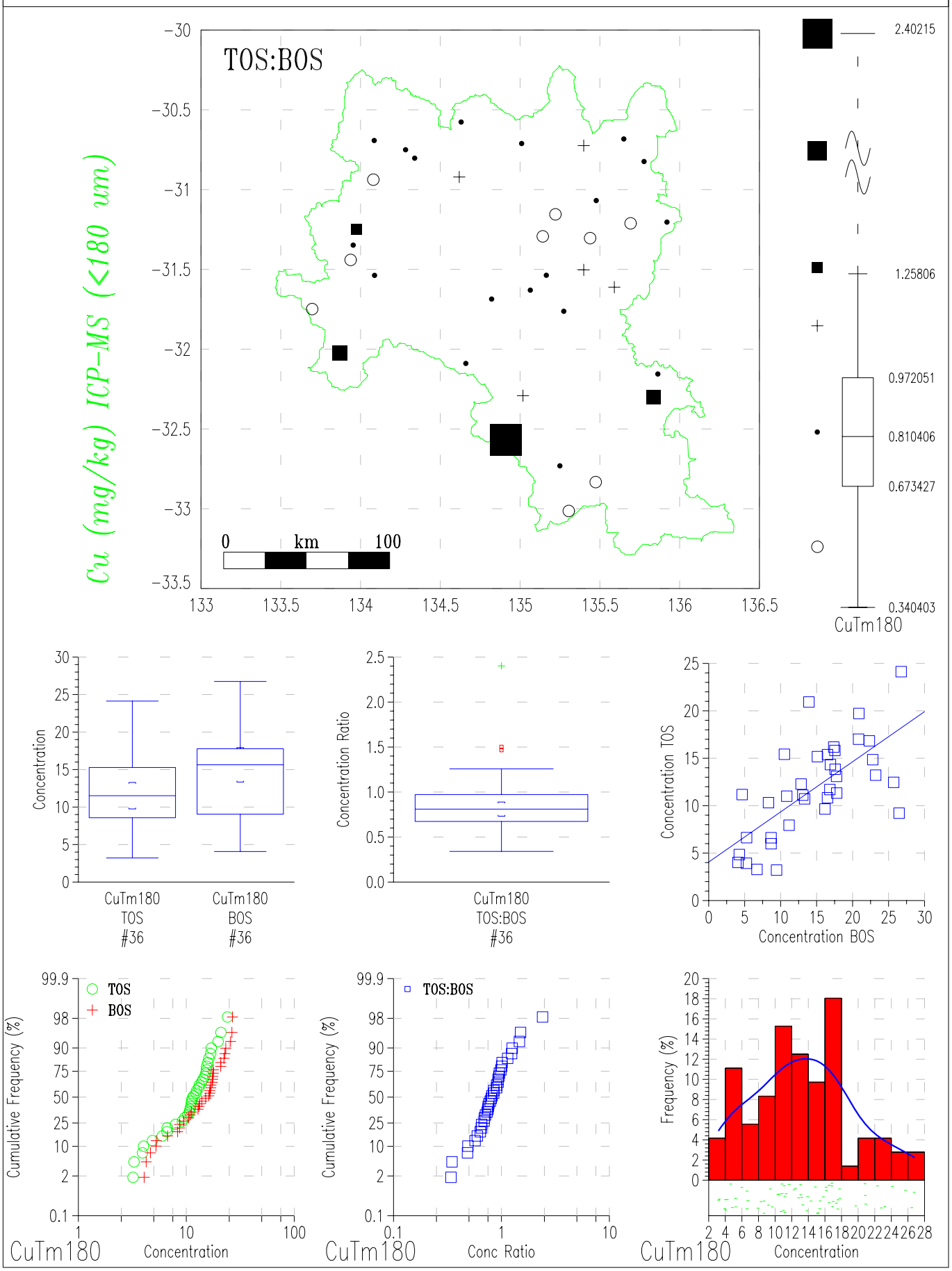
Top & Bottom Outlet Sediments (TOS & BOS)



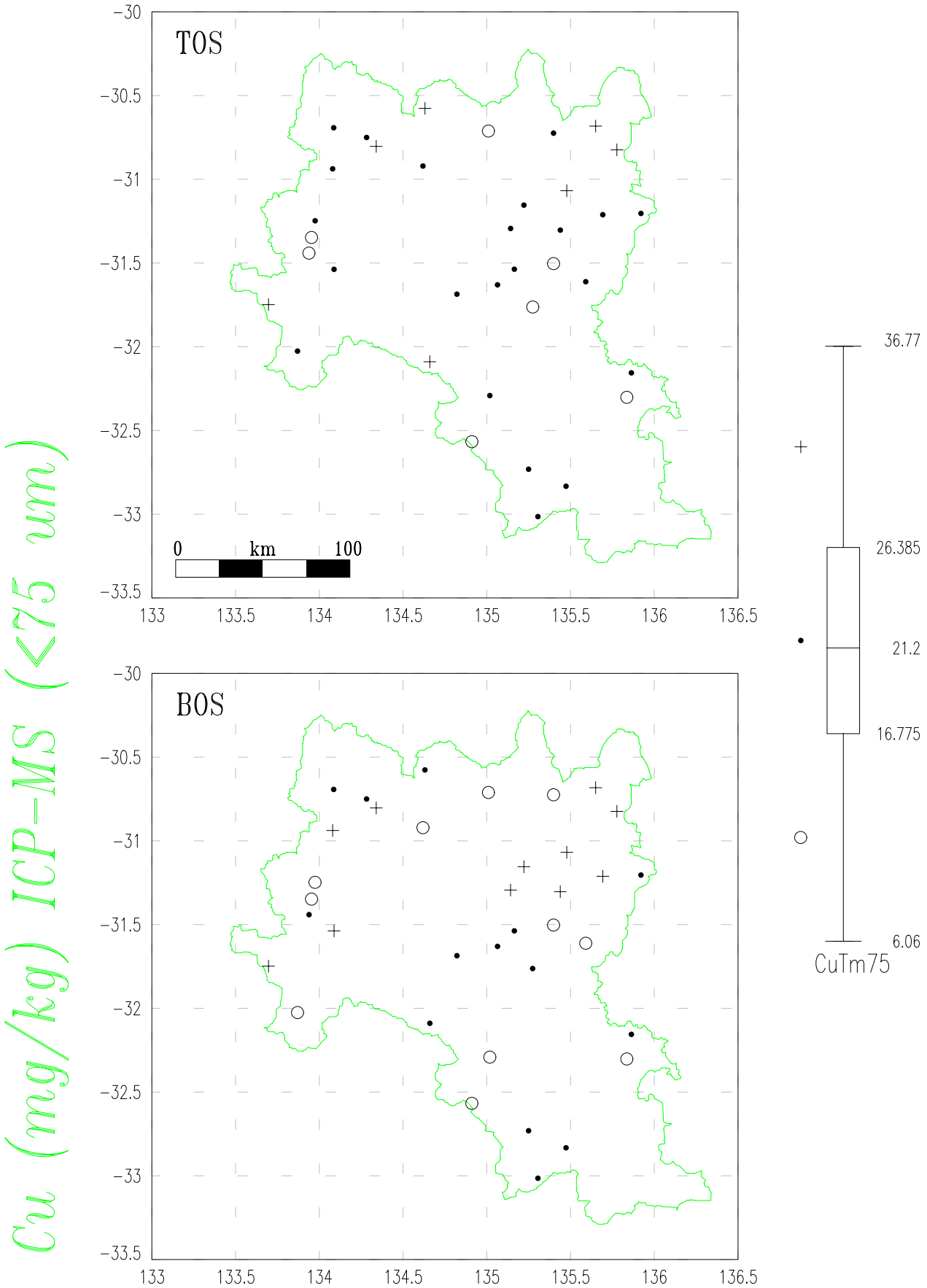
GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



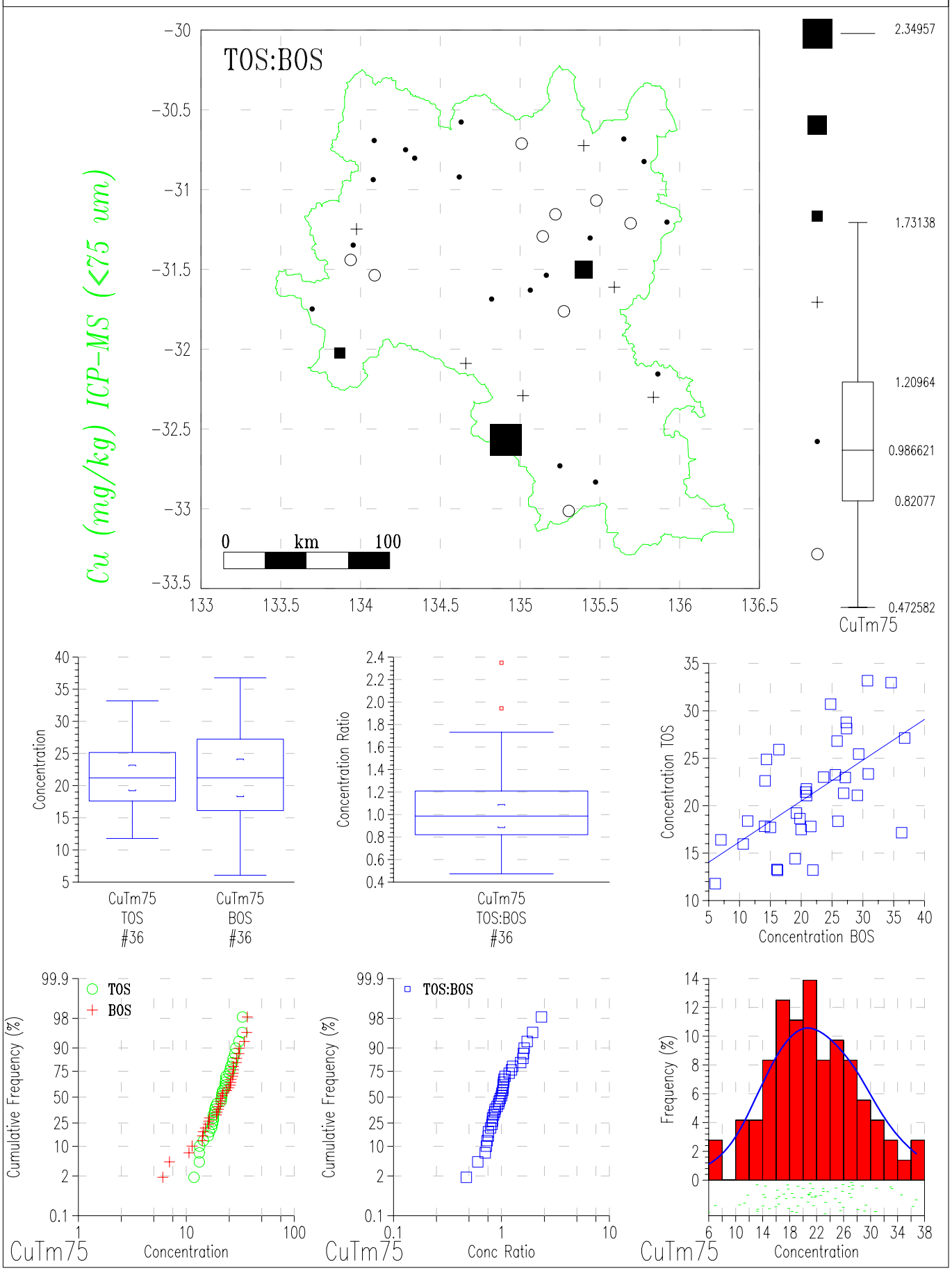
GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



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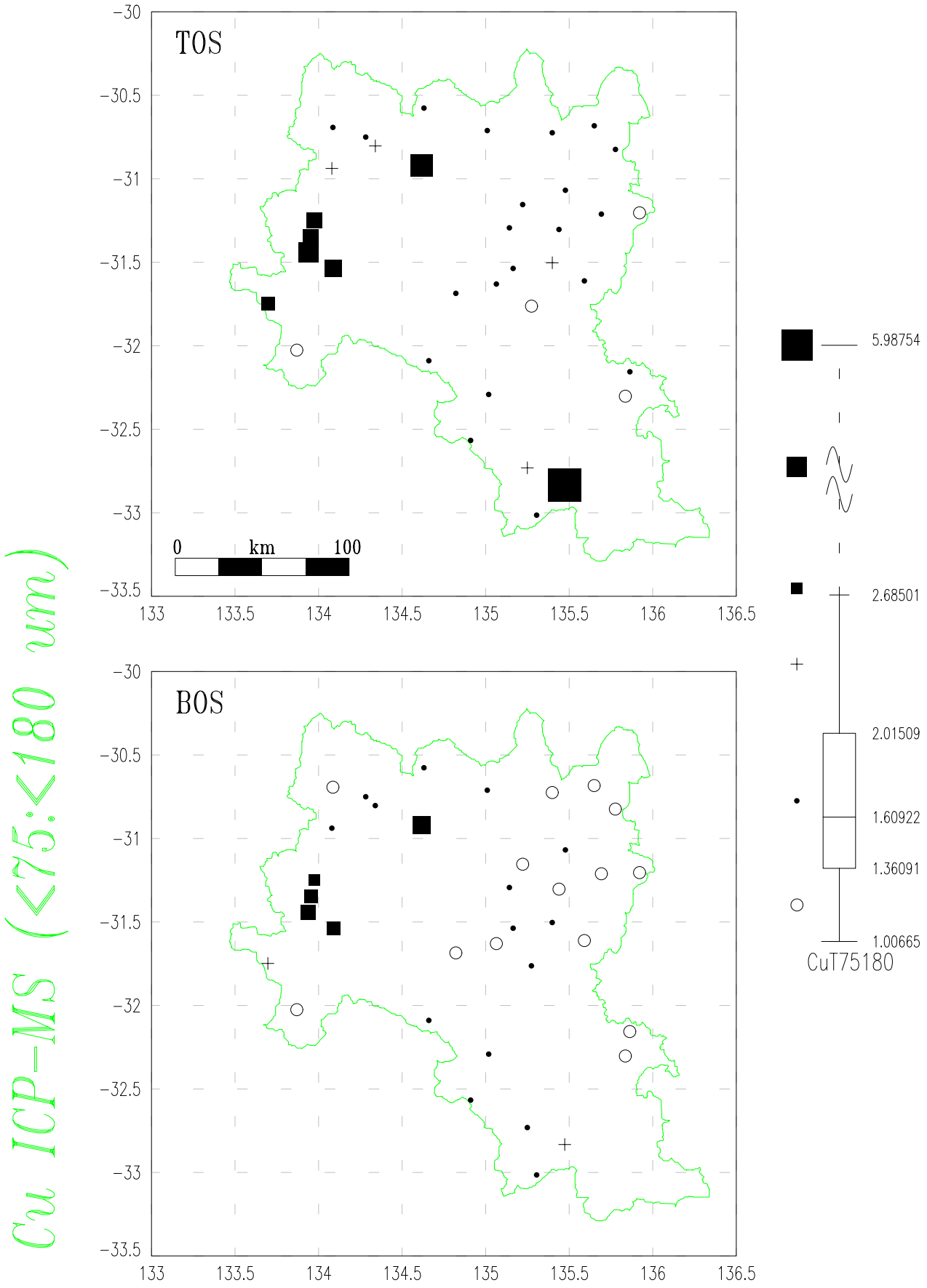
Top & Bottom Outlet Sediments (TOS & BOS)



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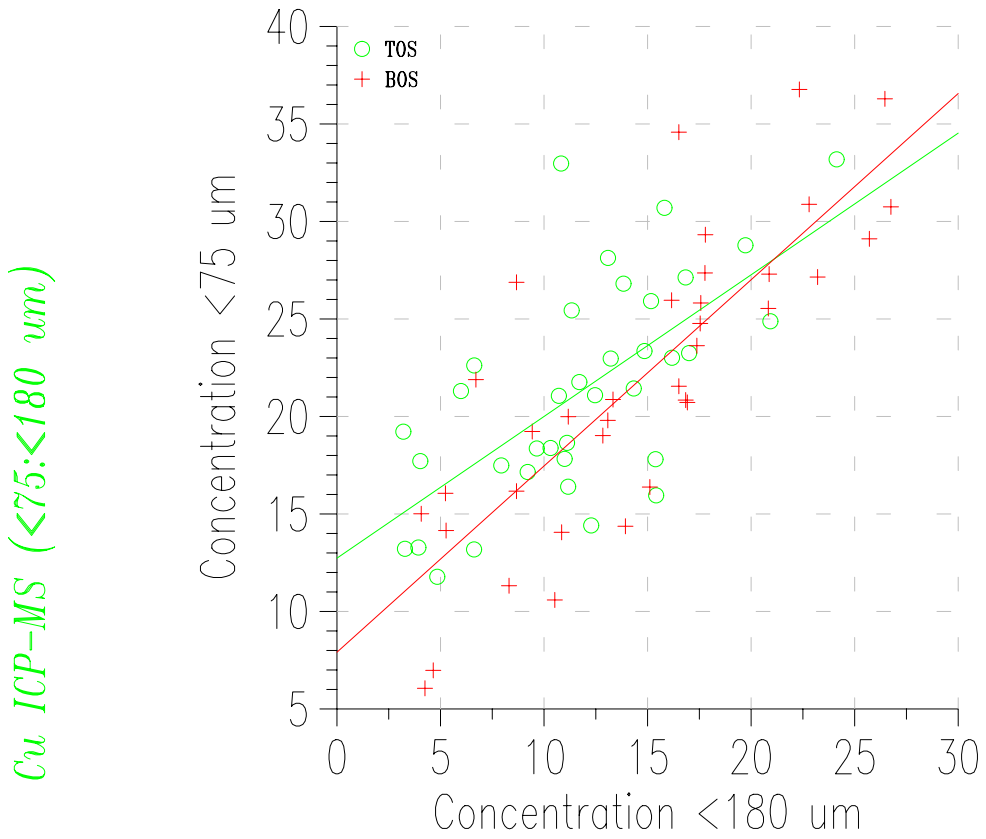
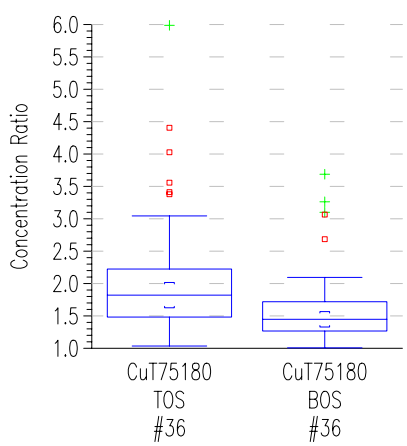
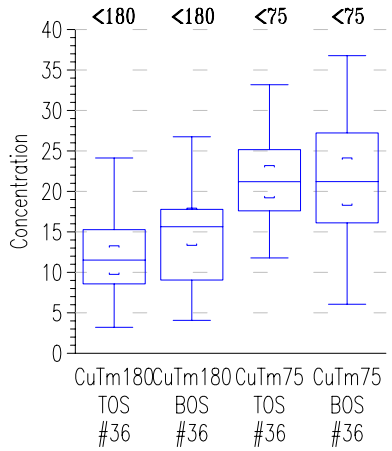
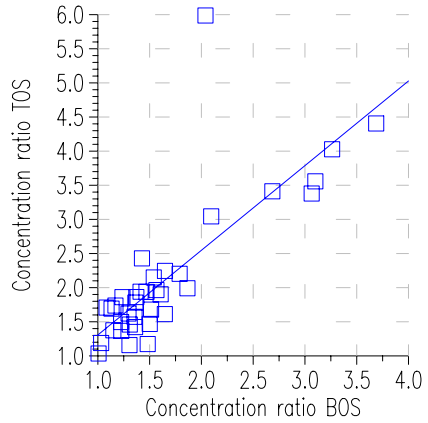
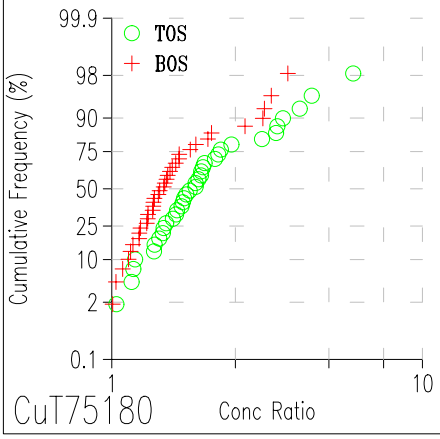
Top & Bottom Outlet Sediments (TOS & BOS)

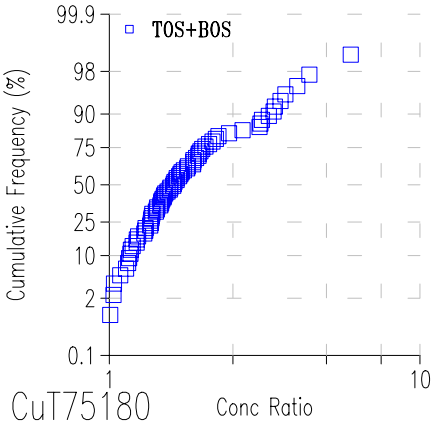


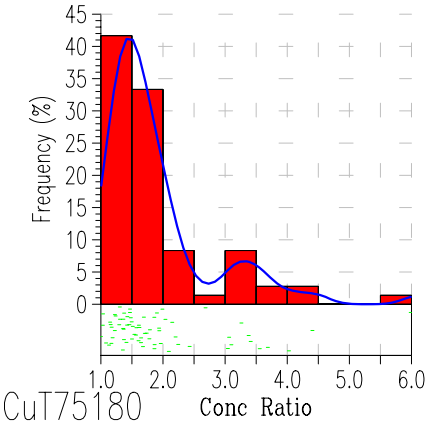






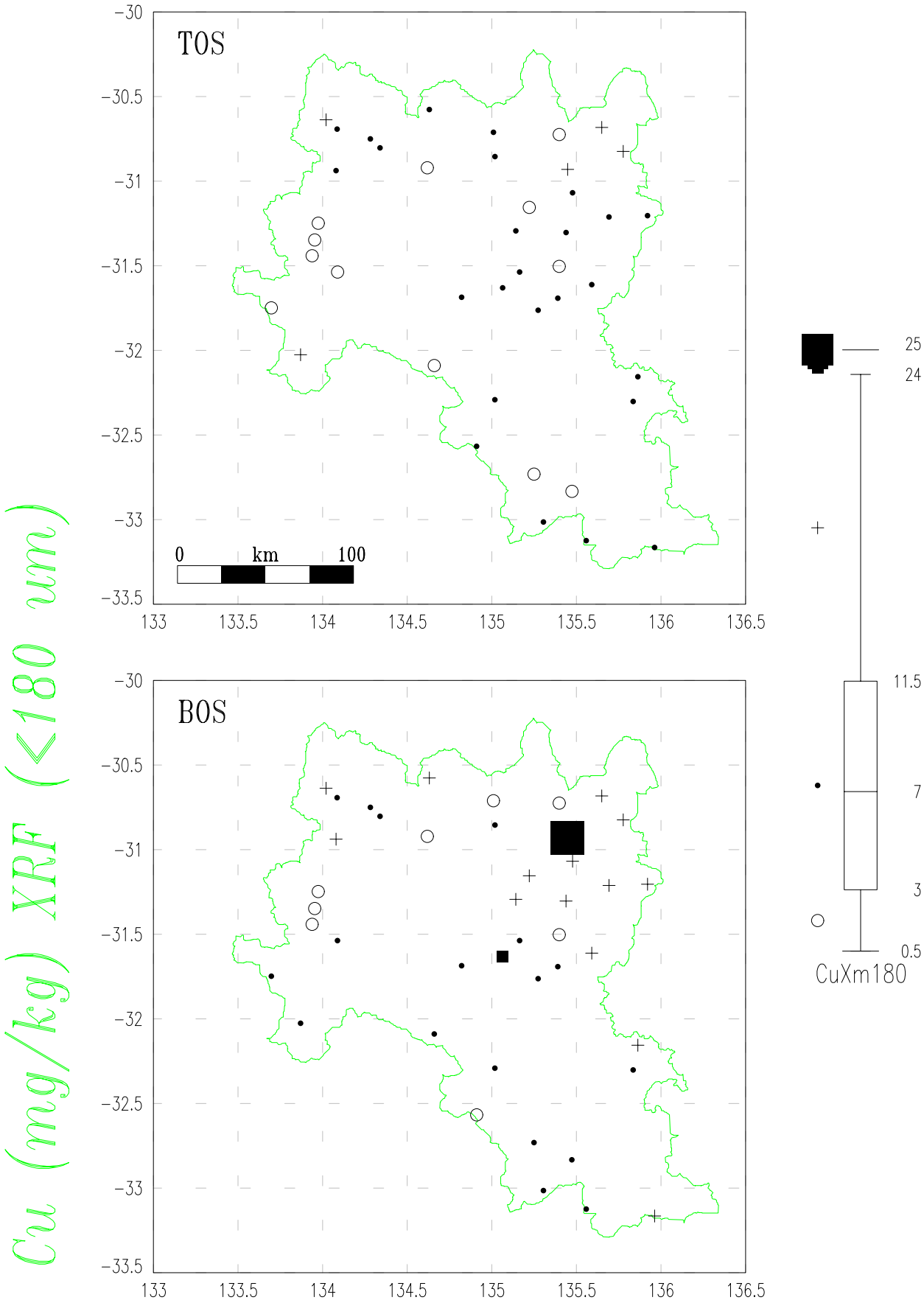






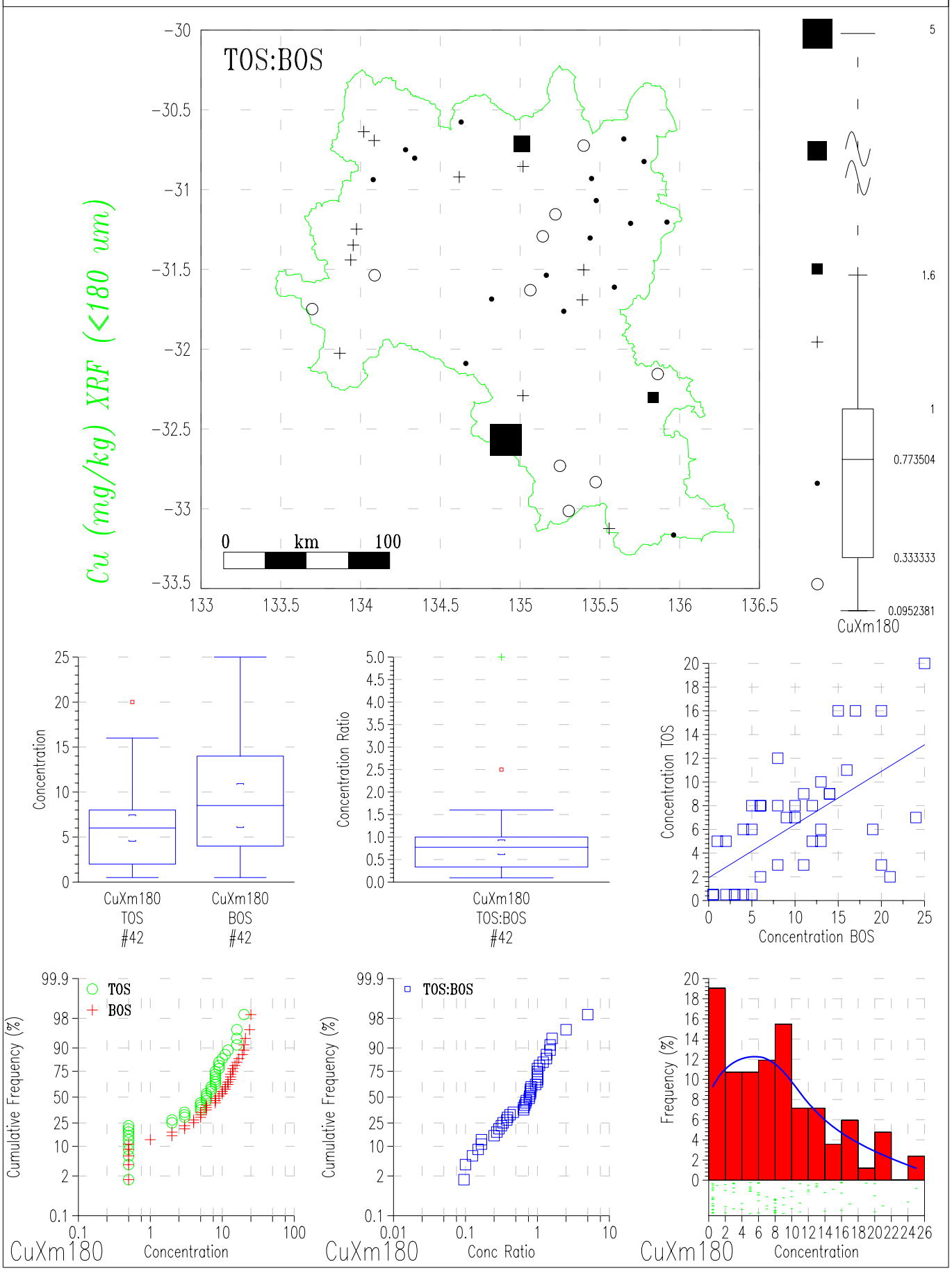
GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



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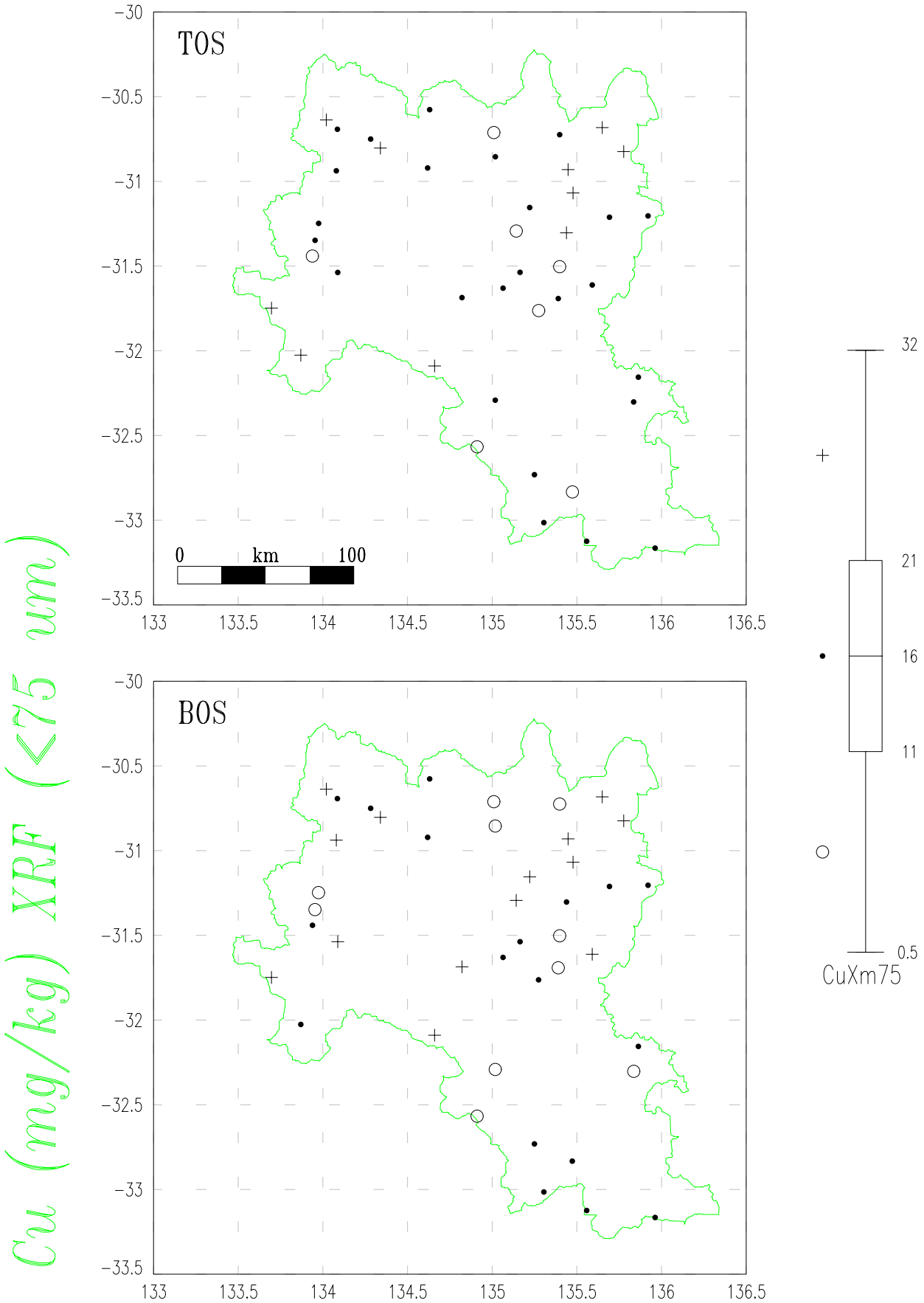
Top & Bottom Outlet Sediments (TOS & BOS)



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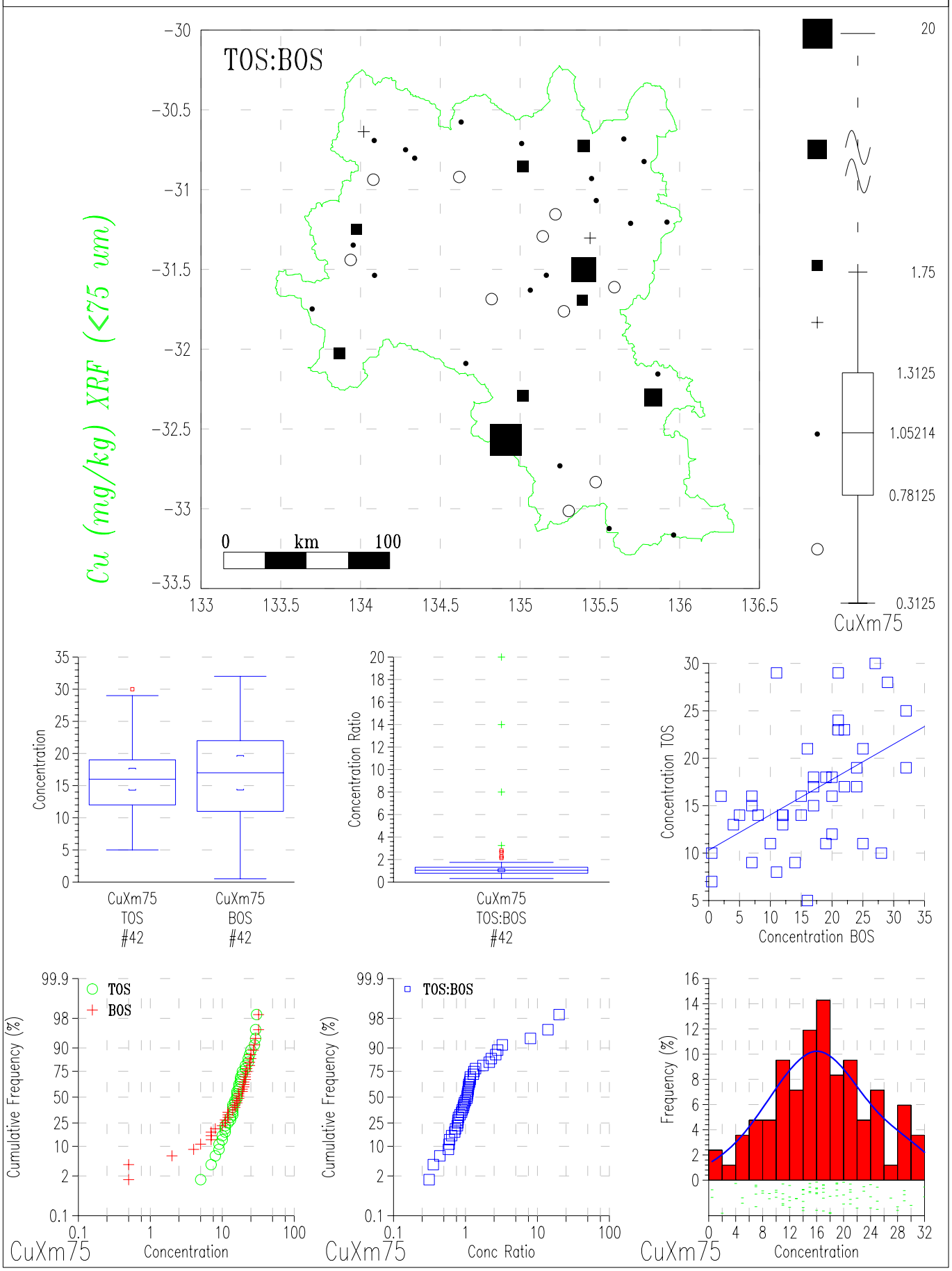
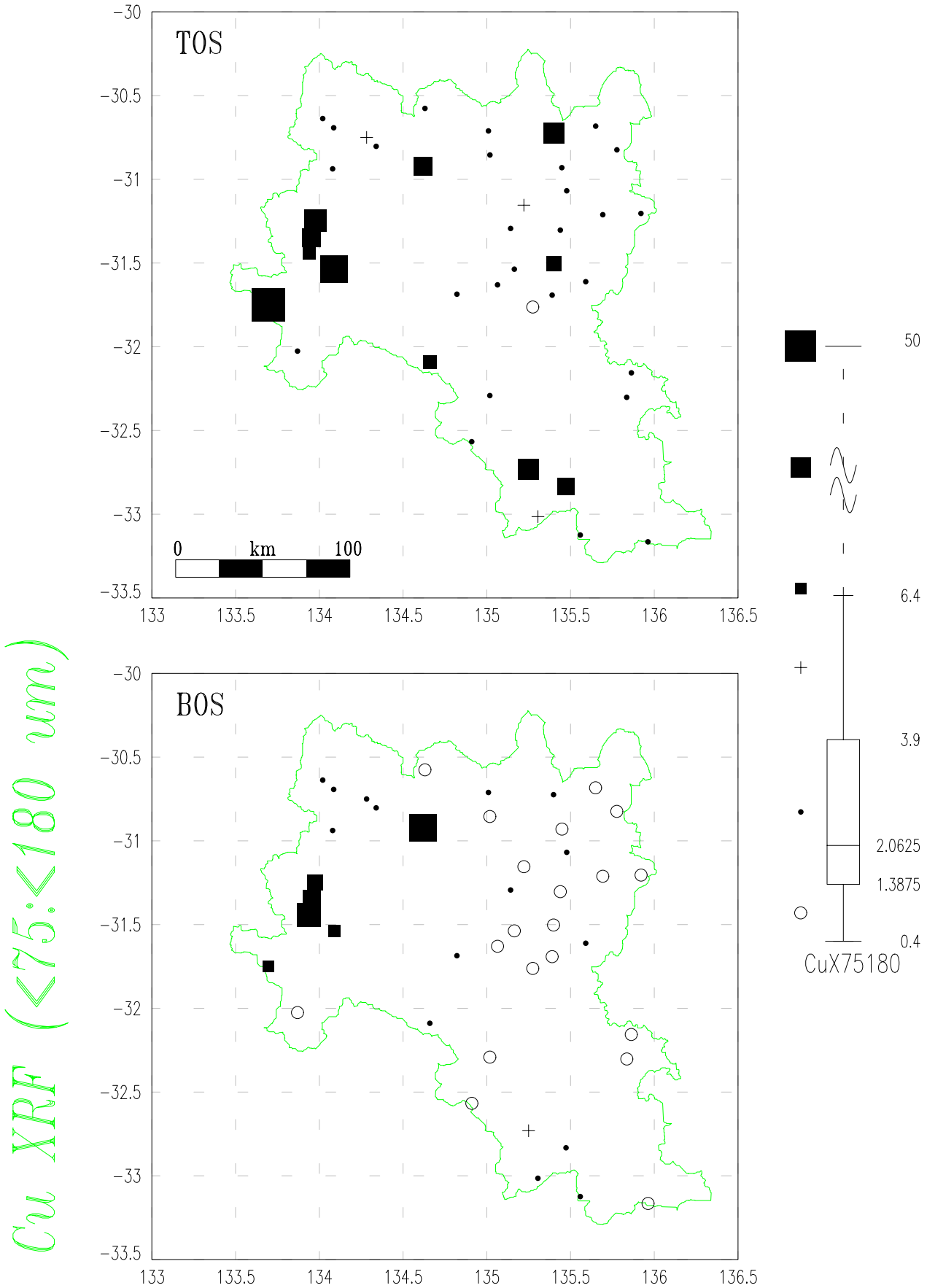
Top & Bottom Outlet Sediments (TOS & BOS)

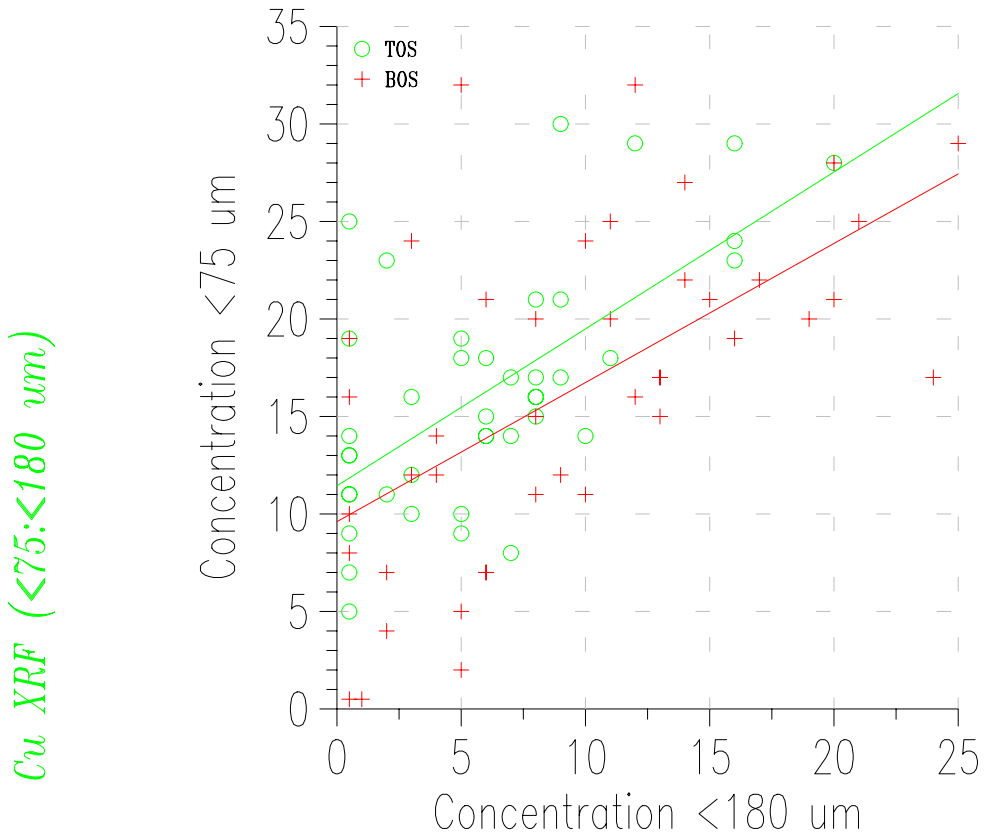


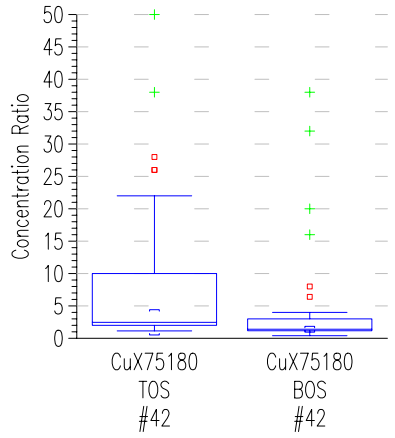
GAWLER GEOCHEMICAL SURVEY

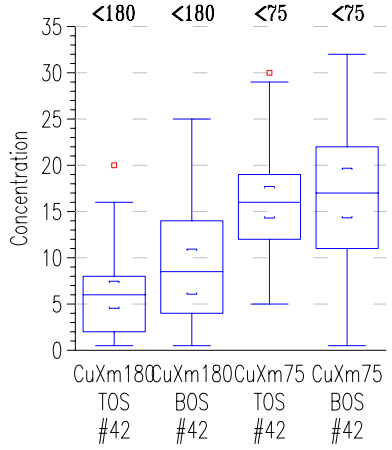
Top & Bottom Outlet Sediments (TOS & BOS)

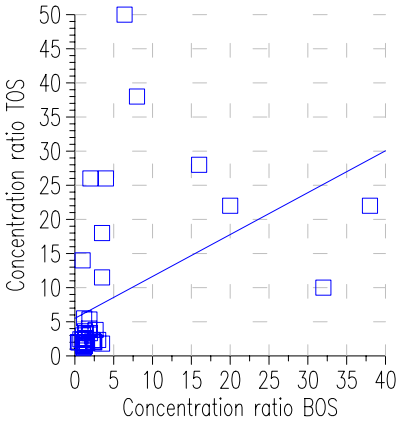


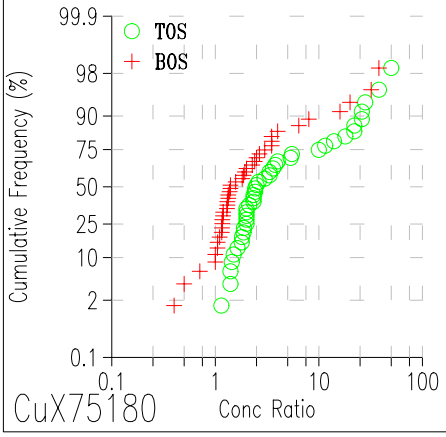
GAWLER GEOCHEMICAL SURVEY *Top & Bottom Outlet Sediments (TOS & BOS)*

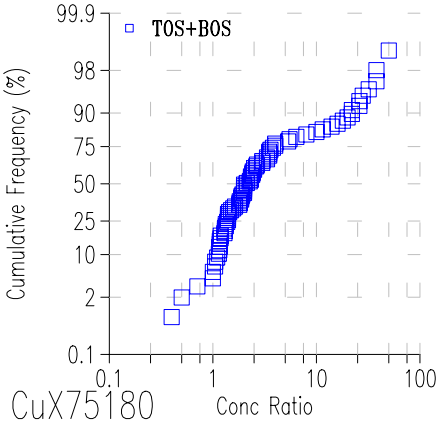


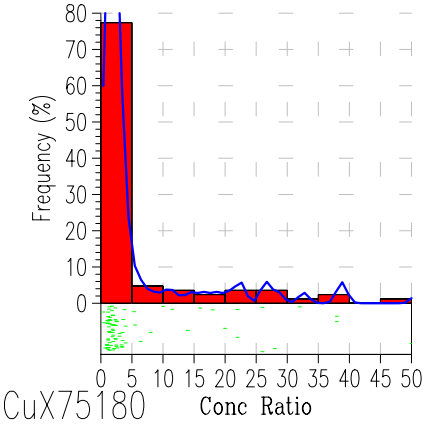








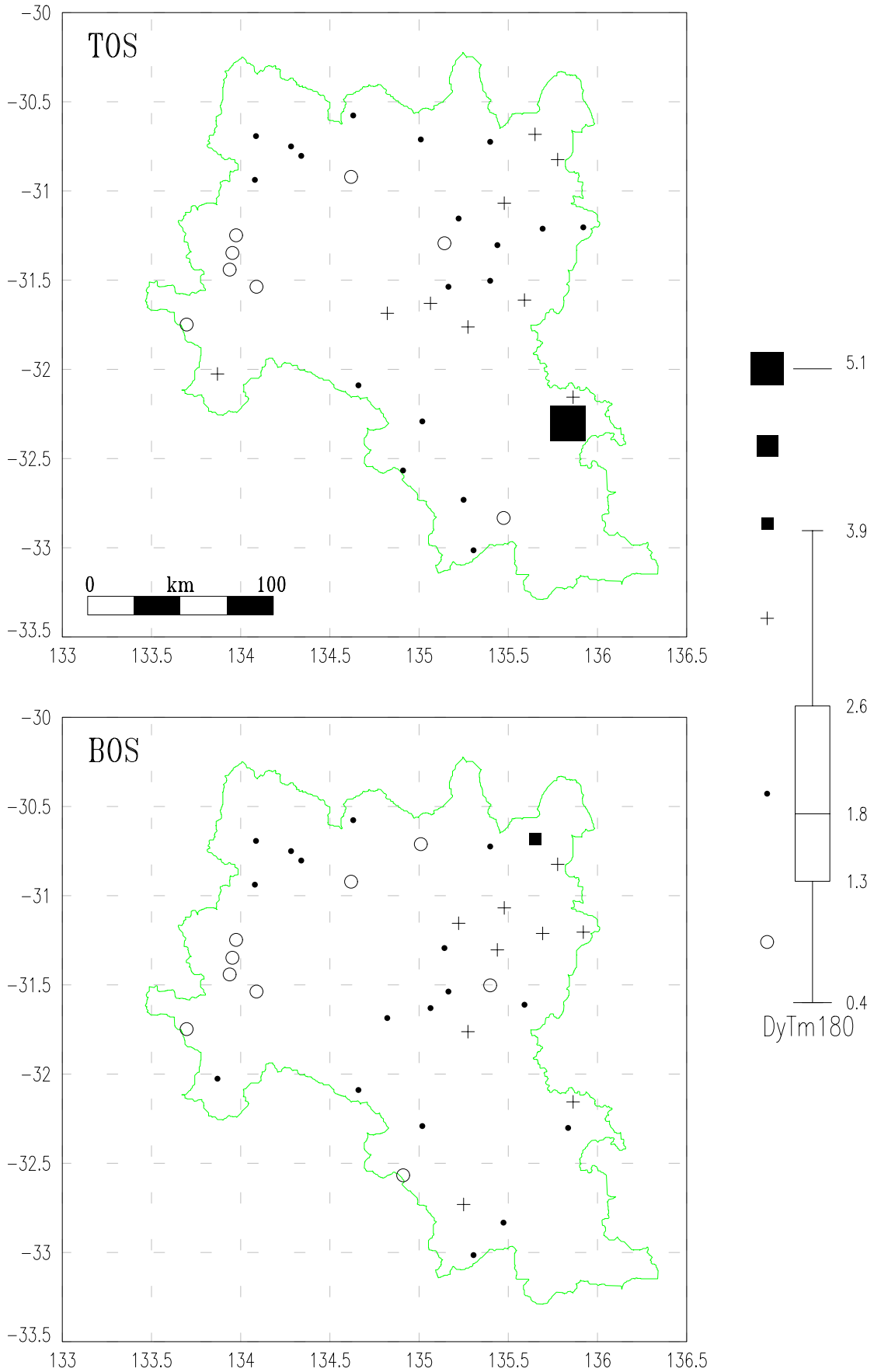




GAWLER GEOCHEMICAL SURVEY

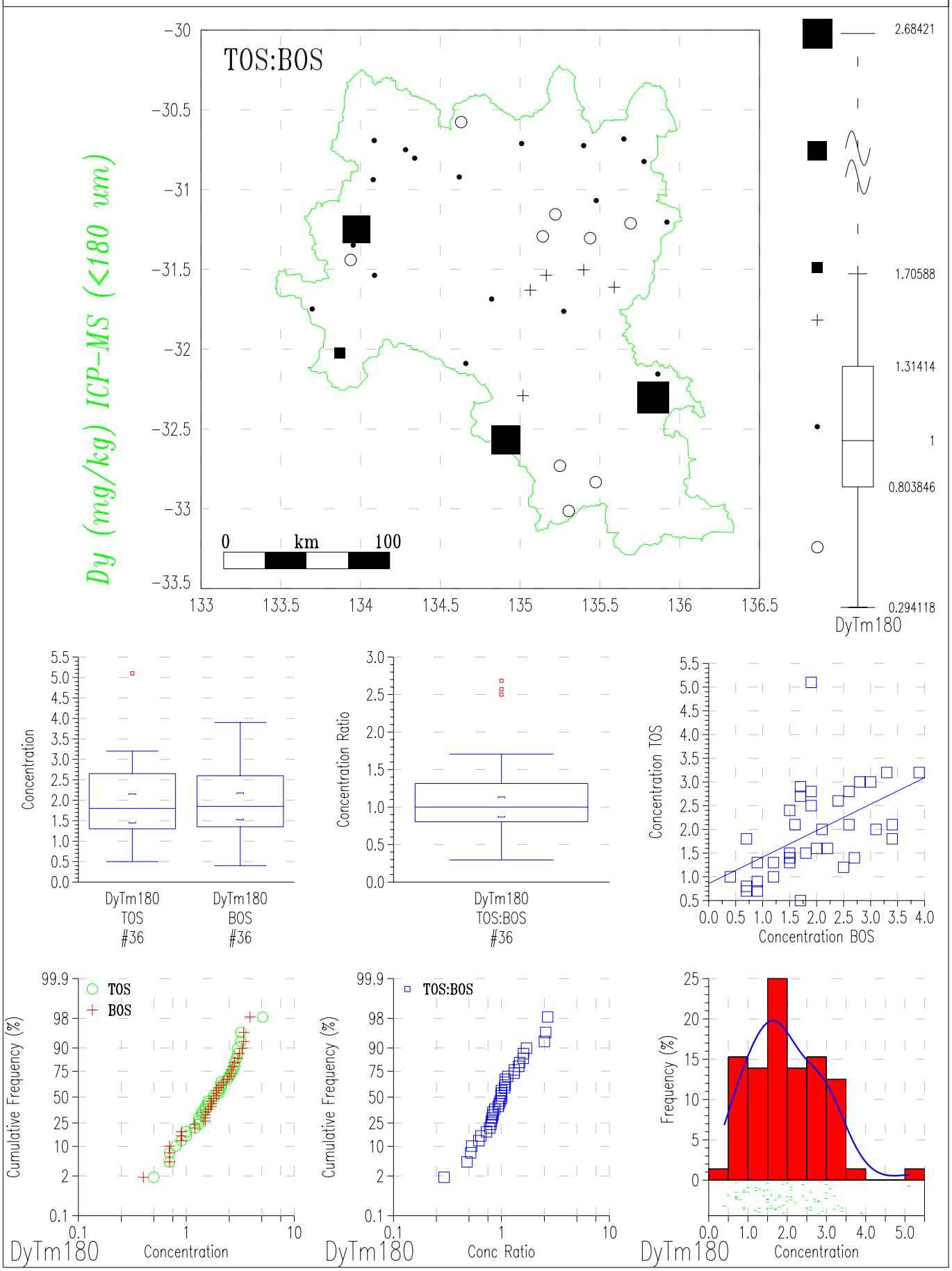
Top & Bottom Outlet Sediments (TOS & BOS)

Dy (mg/kg) ICP-MS (<180 um)



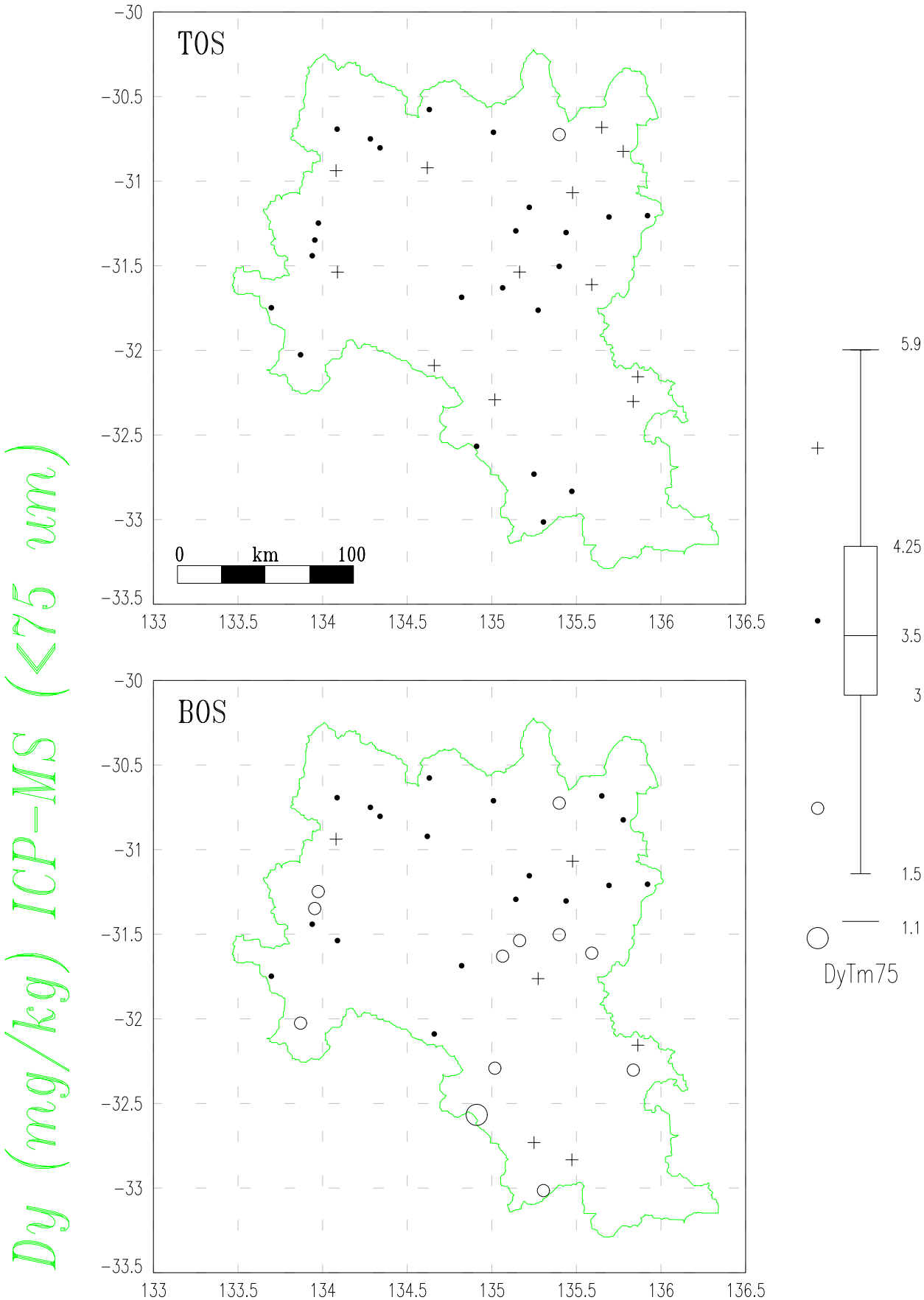
GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



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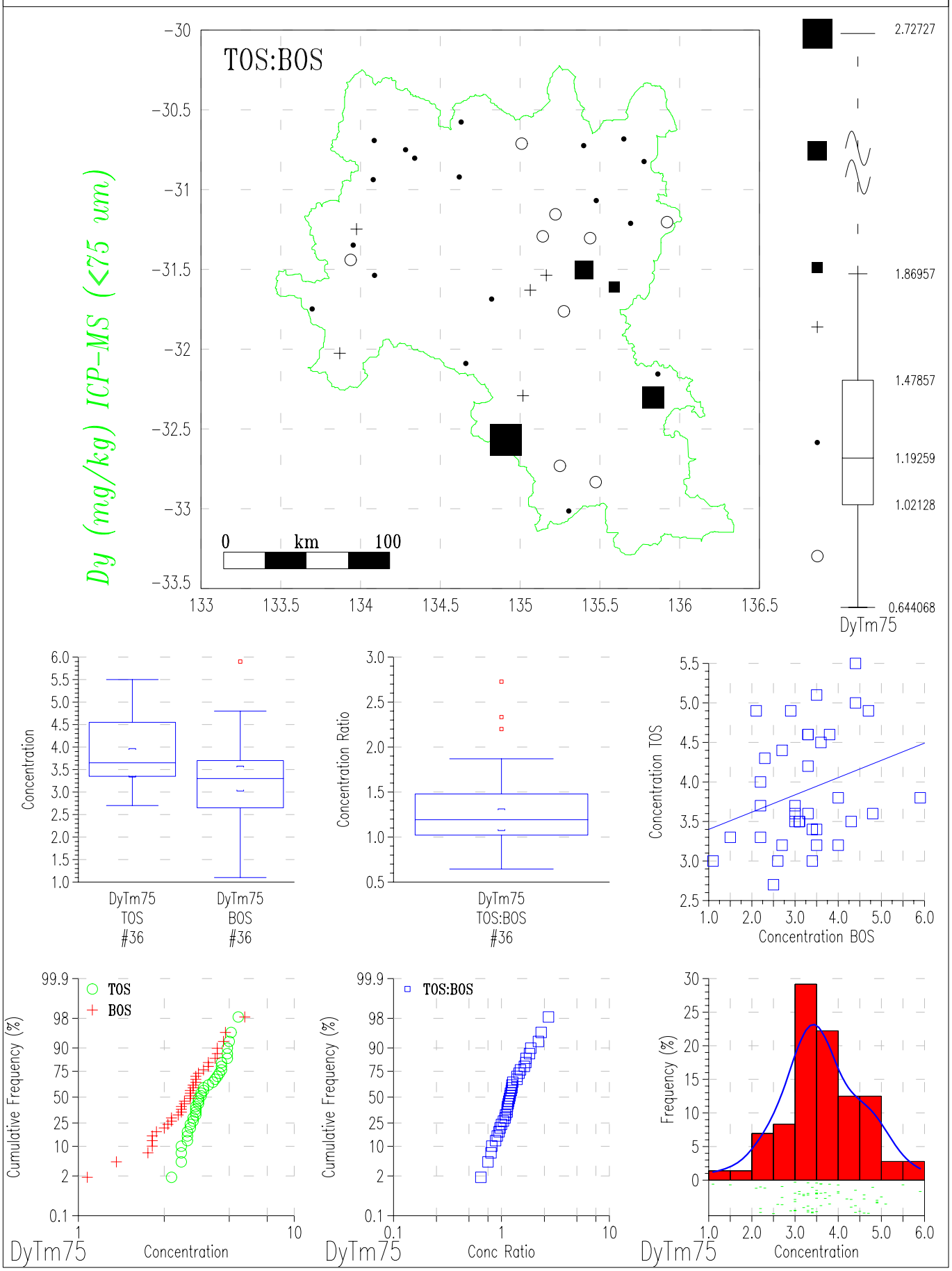
Top & Bottom Outlet Sediments (TOS & BOS)



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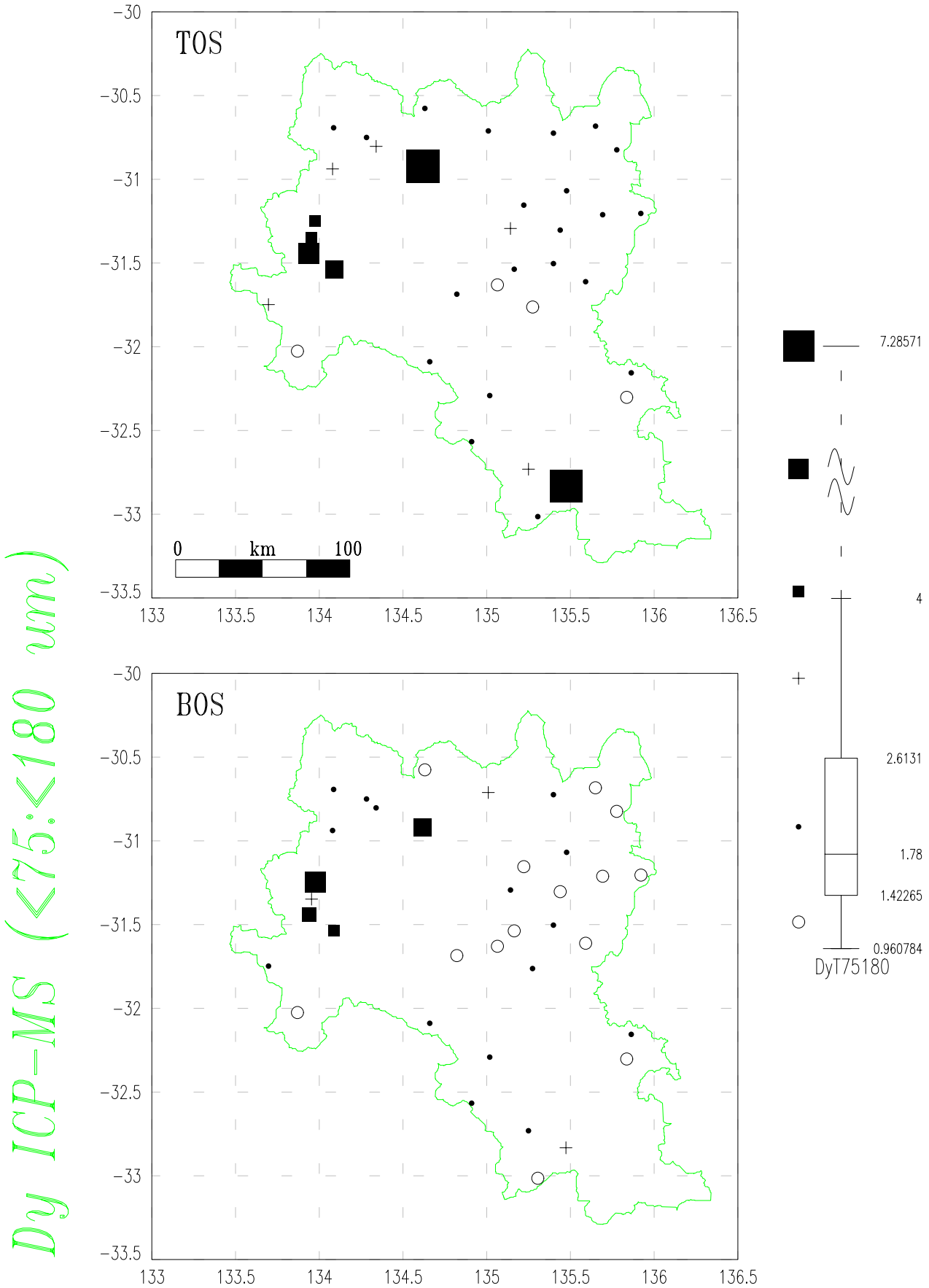
Top & Bottom Outlet Sediments (TOS & BOS)



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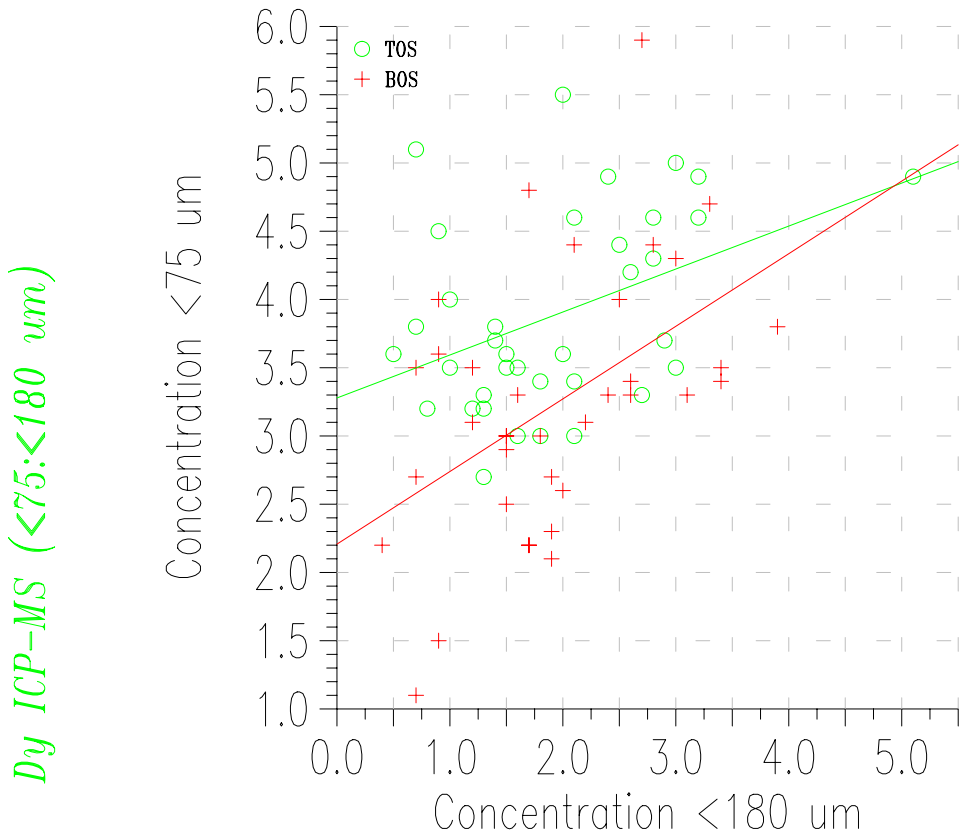
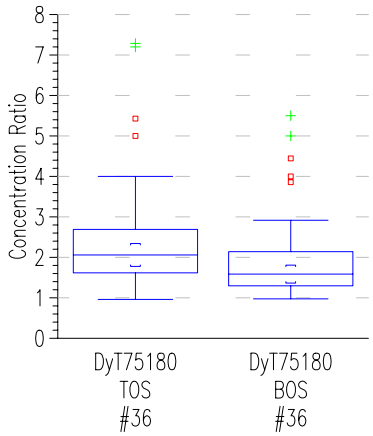
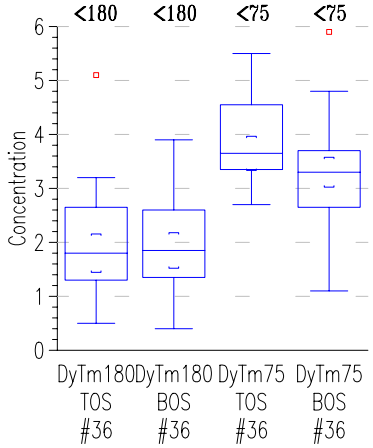
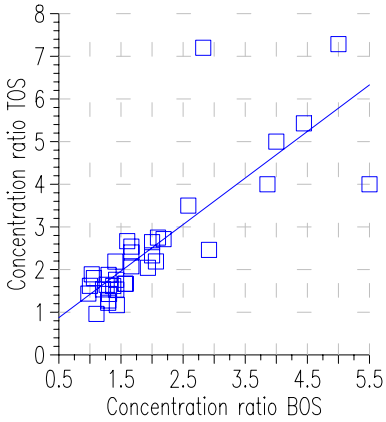
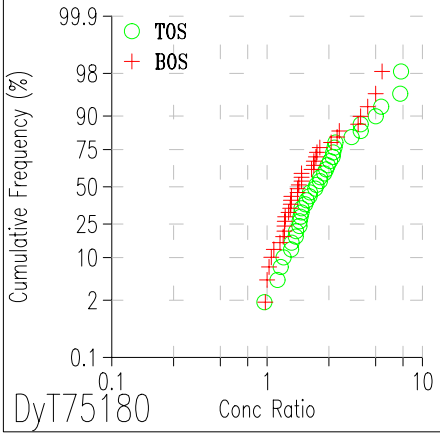
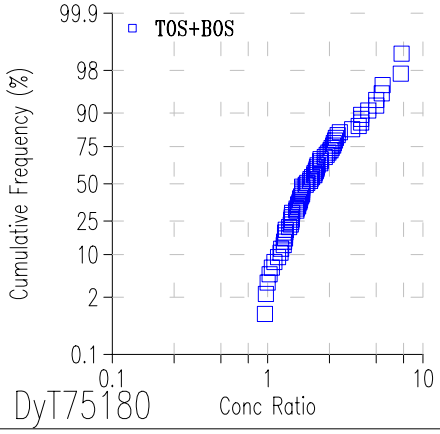


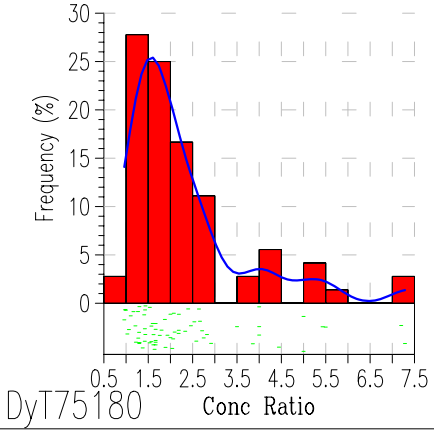






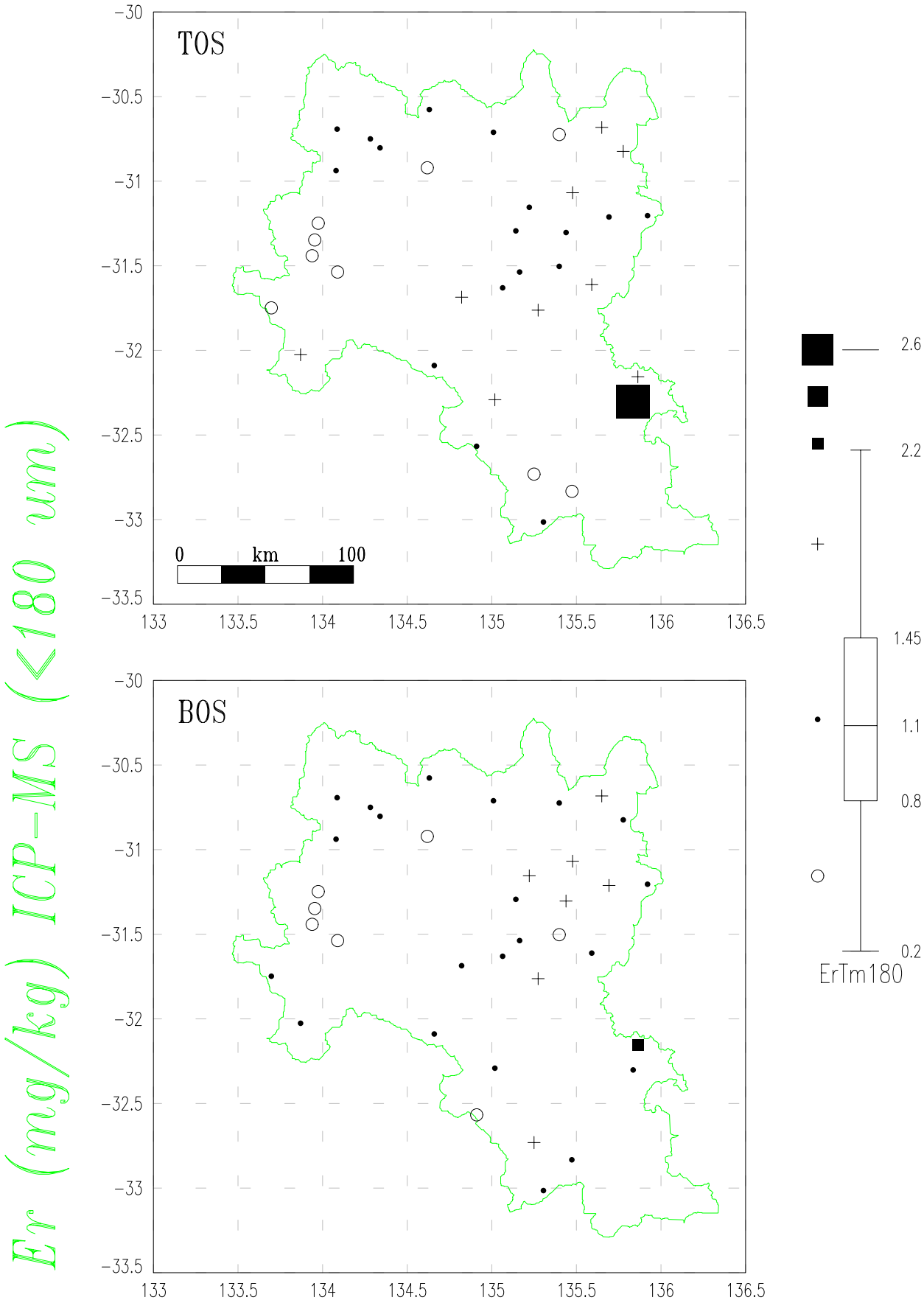






GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



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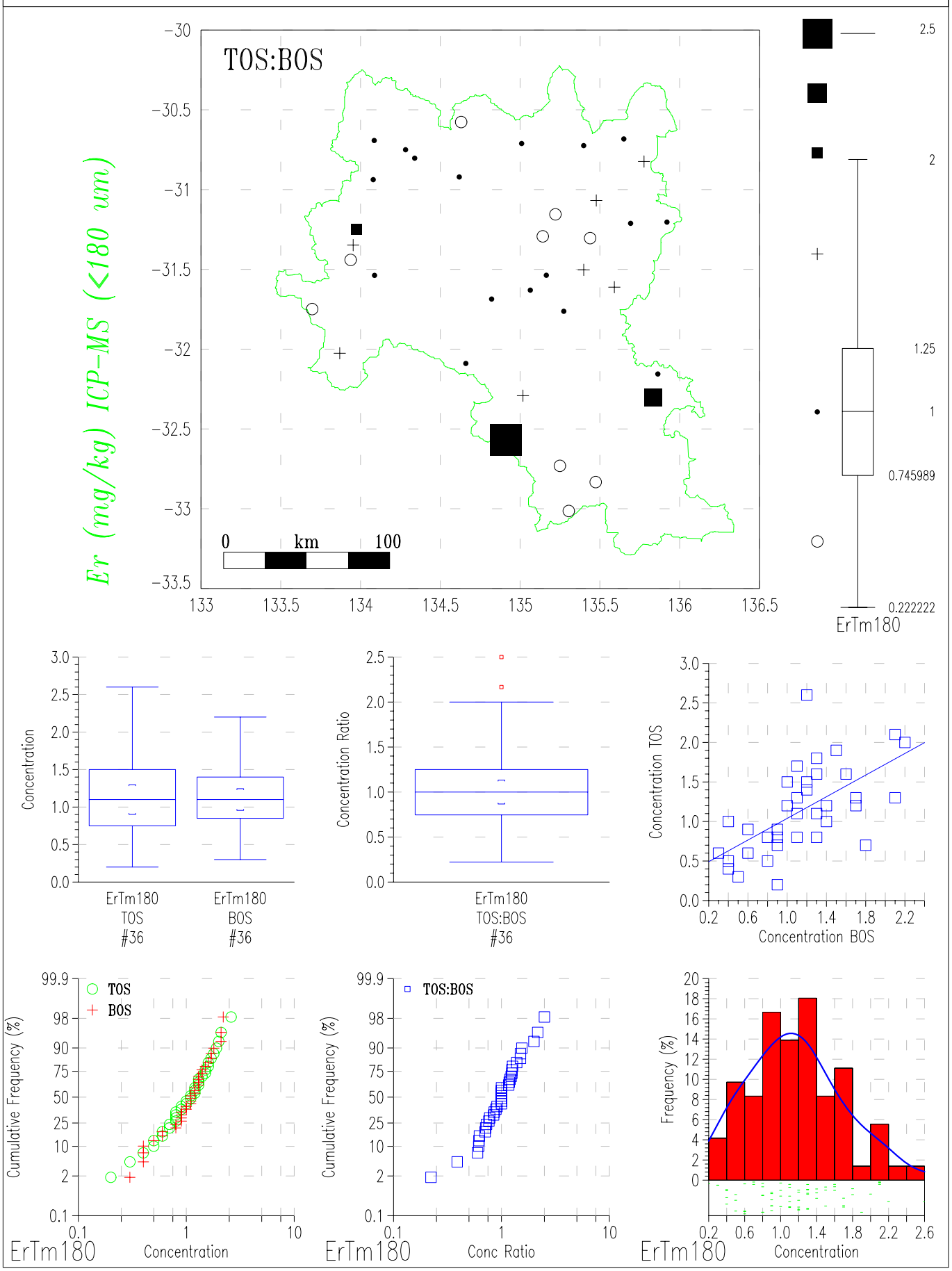

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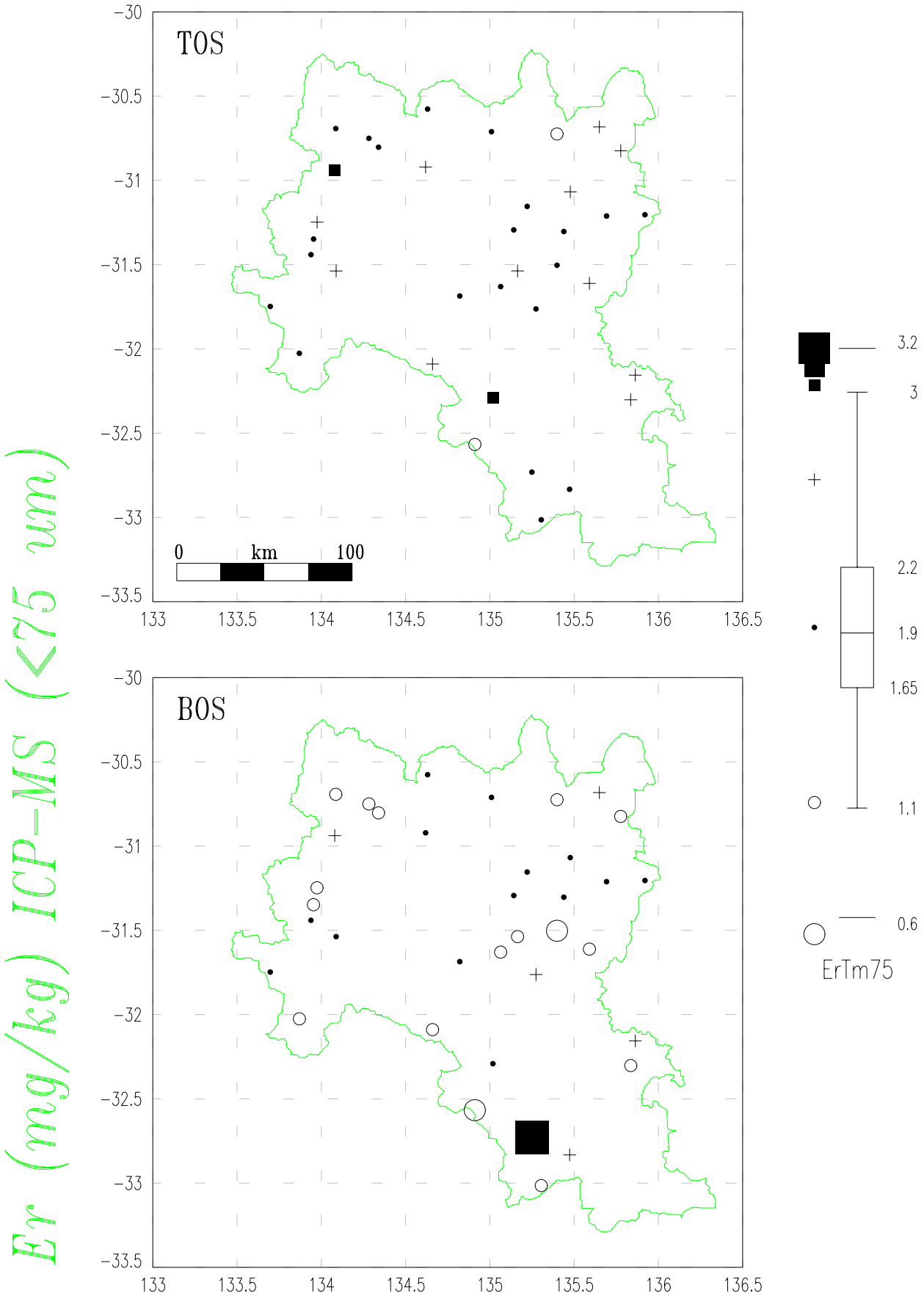

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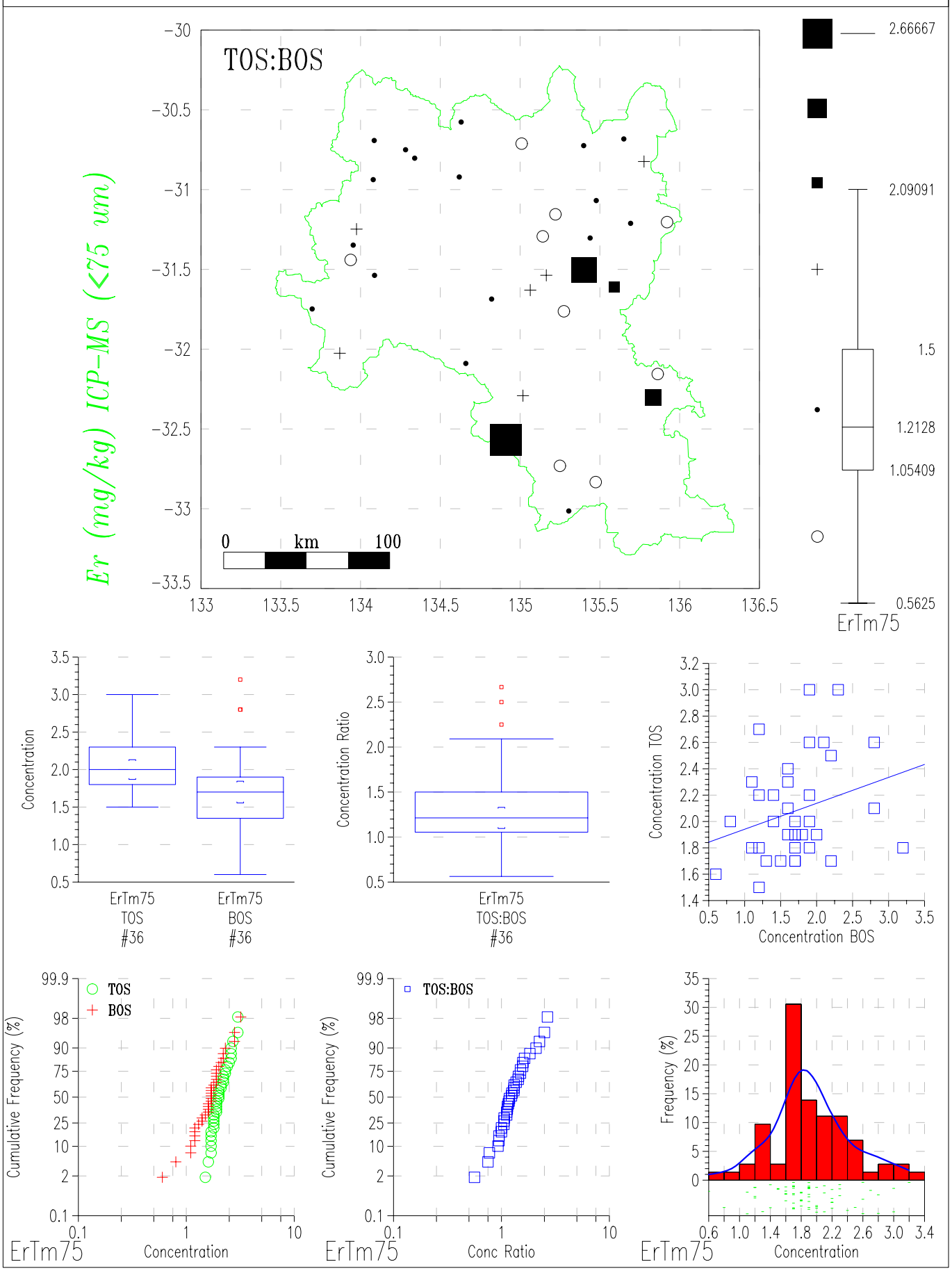

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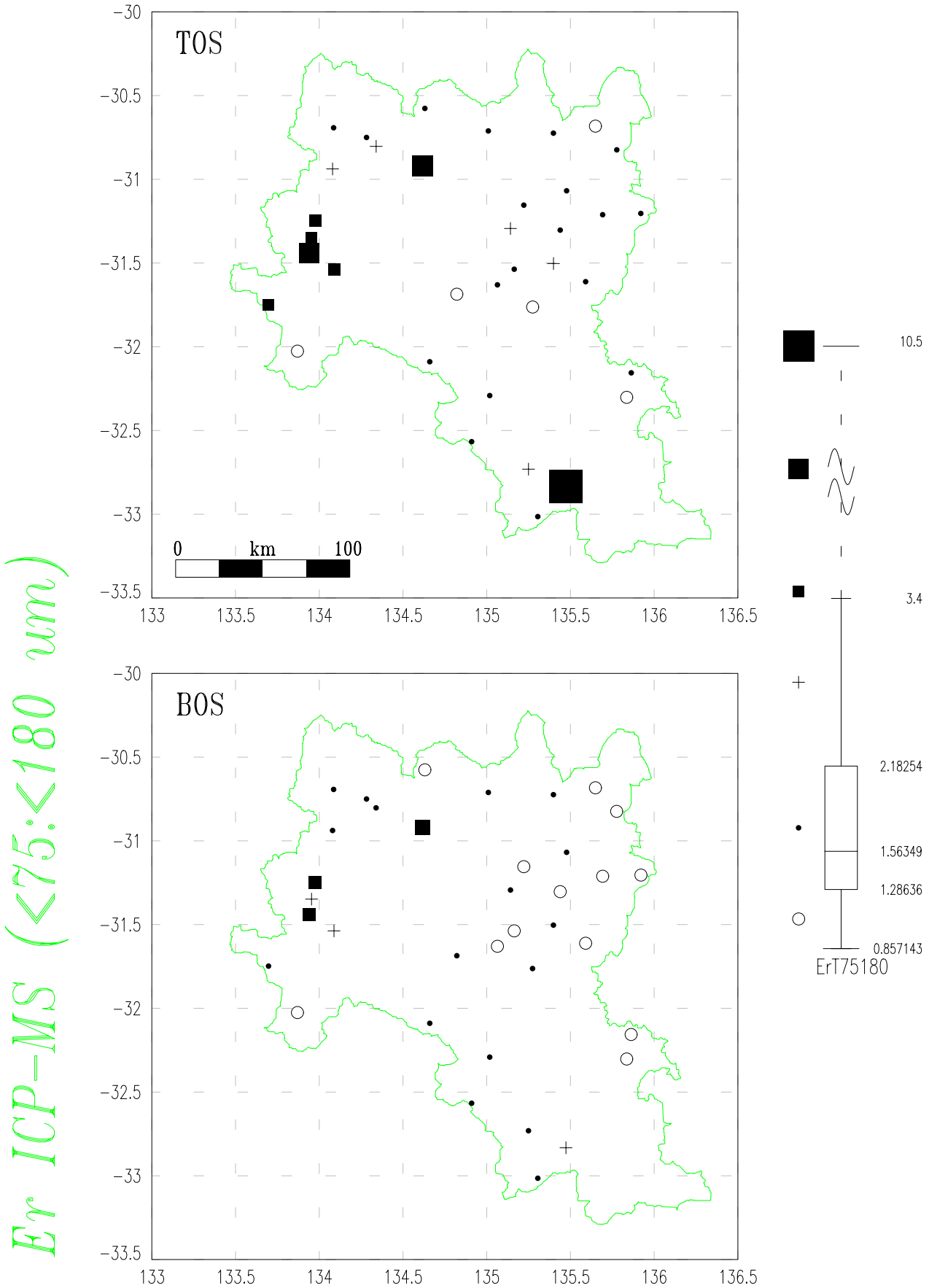

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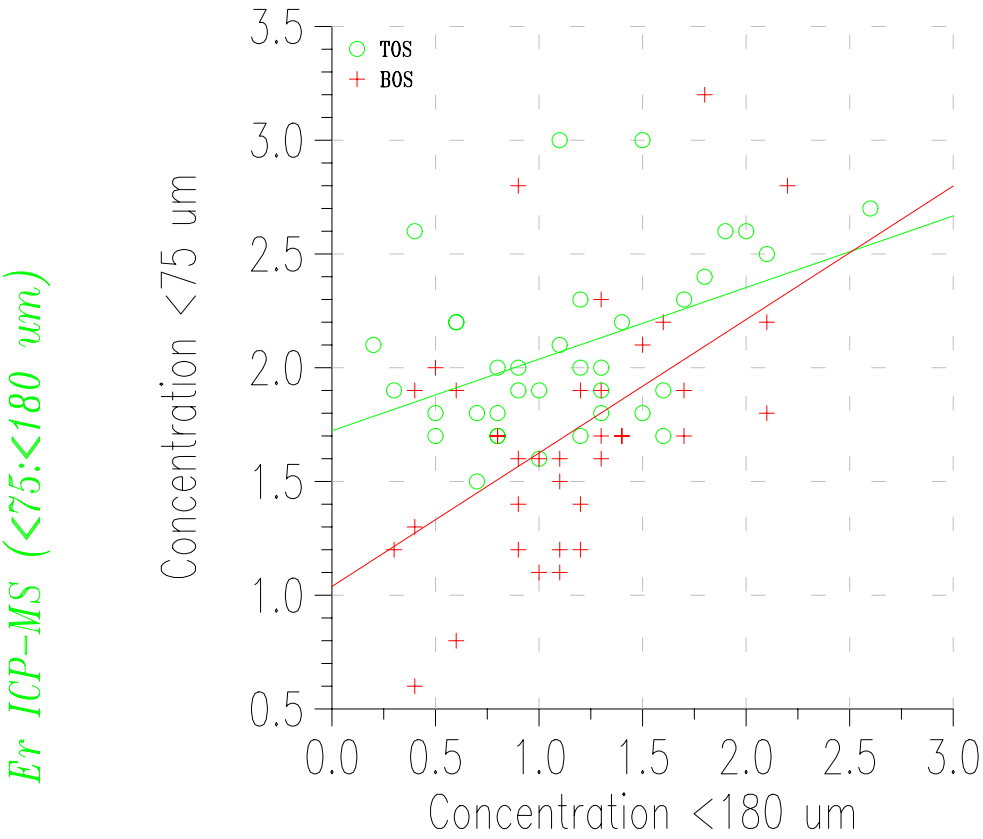
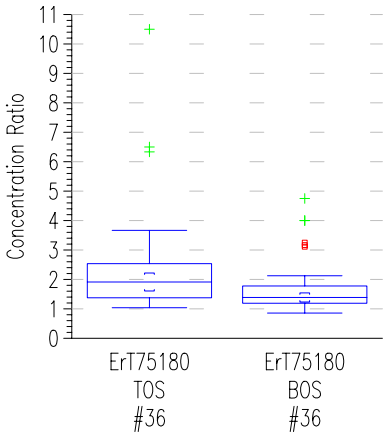
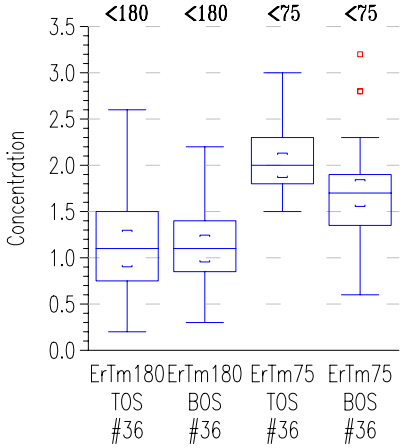
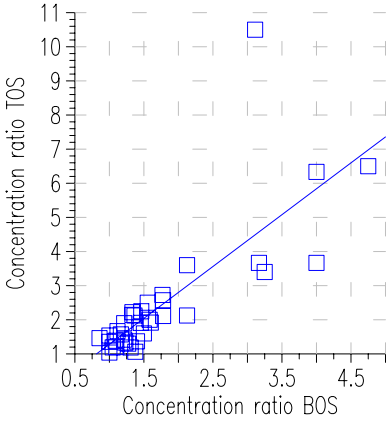
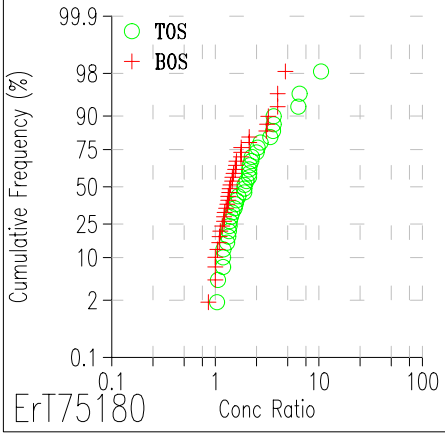
Top & Bottom Outlet Sediments (TOS & BOS)

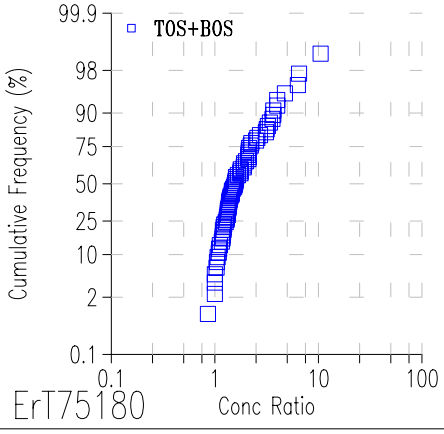


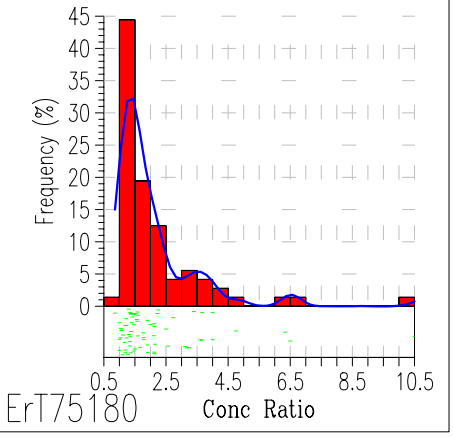






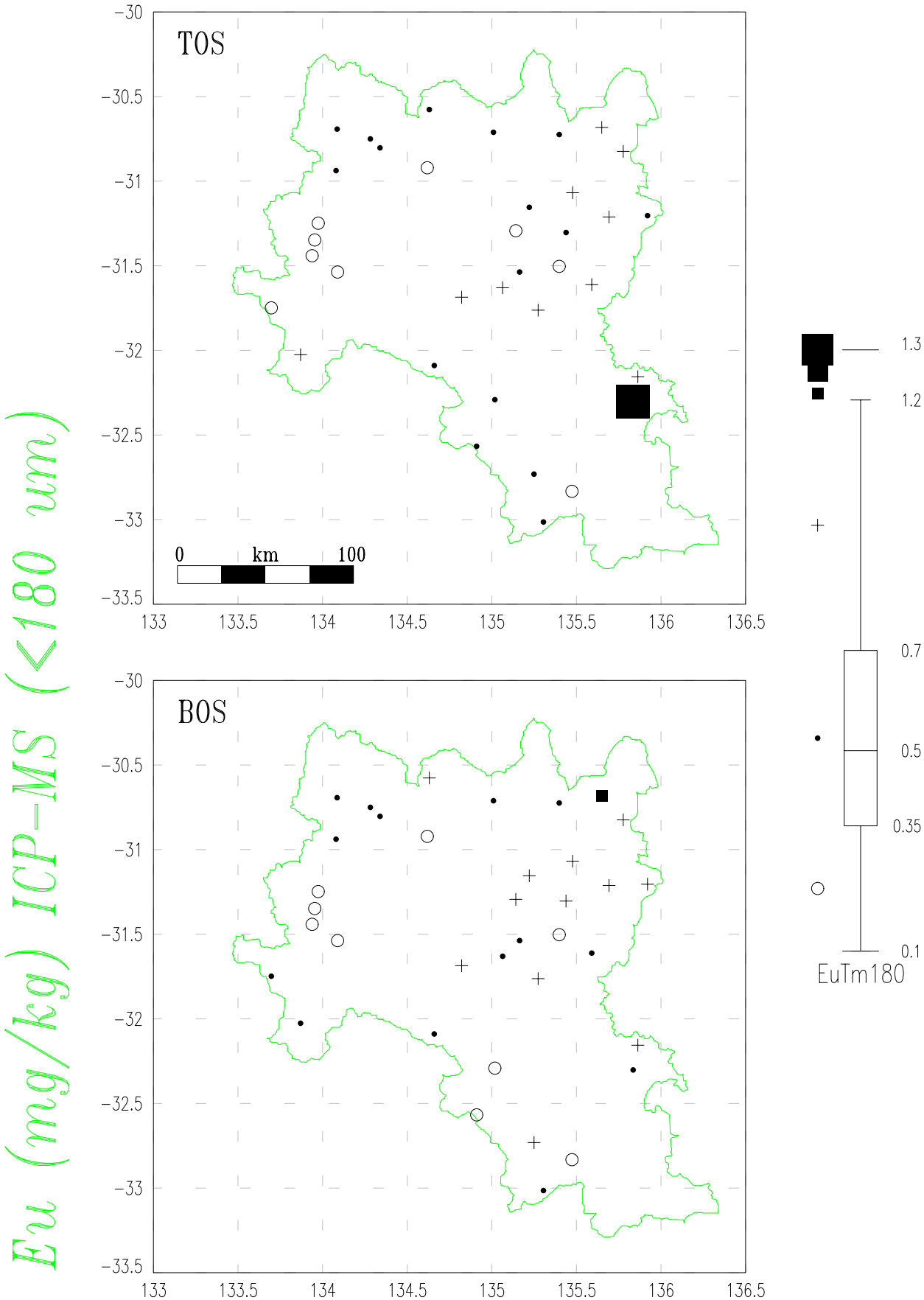






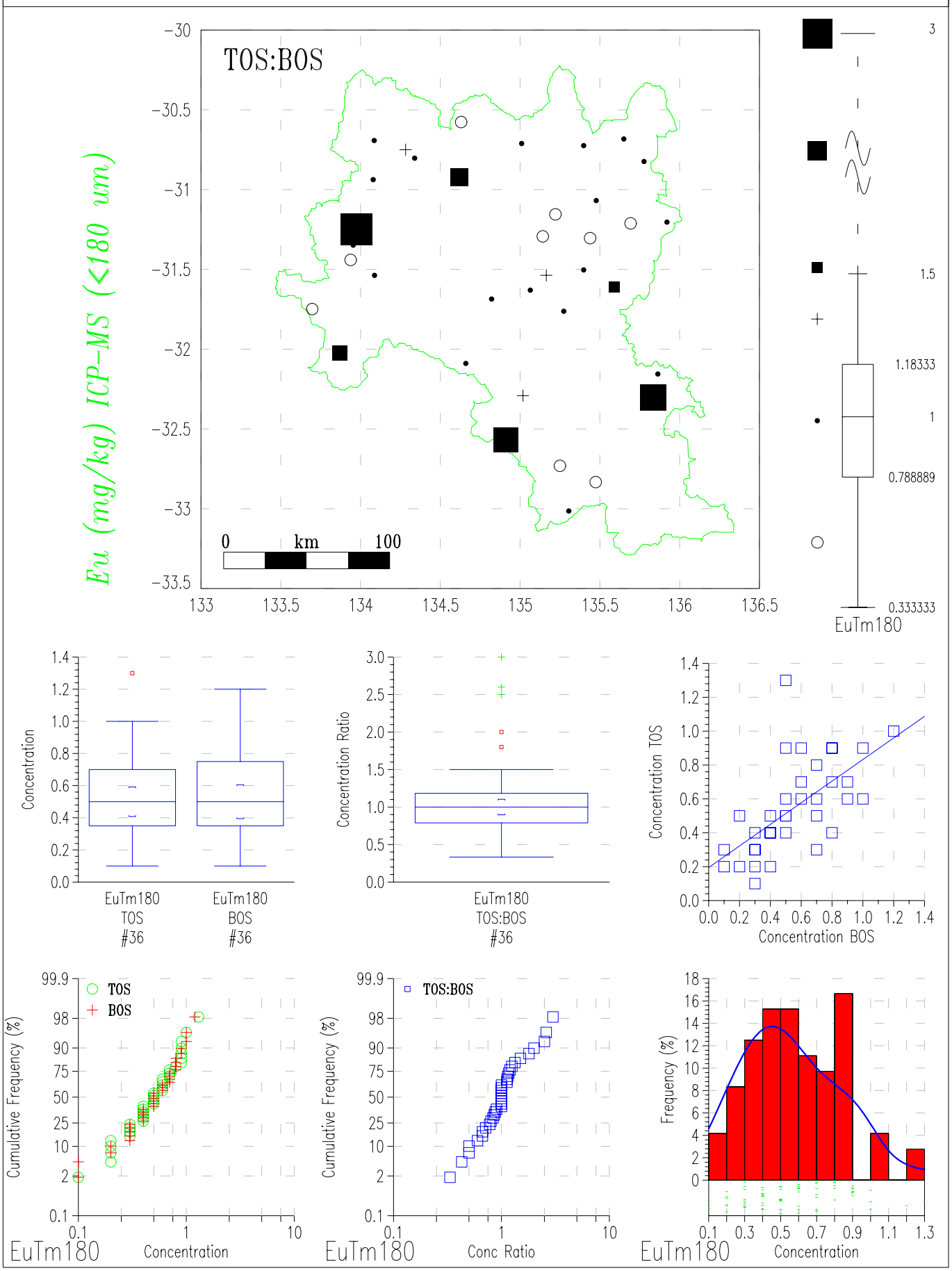
GAWLER GEOCHEMICAL SURVEY

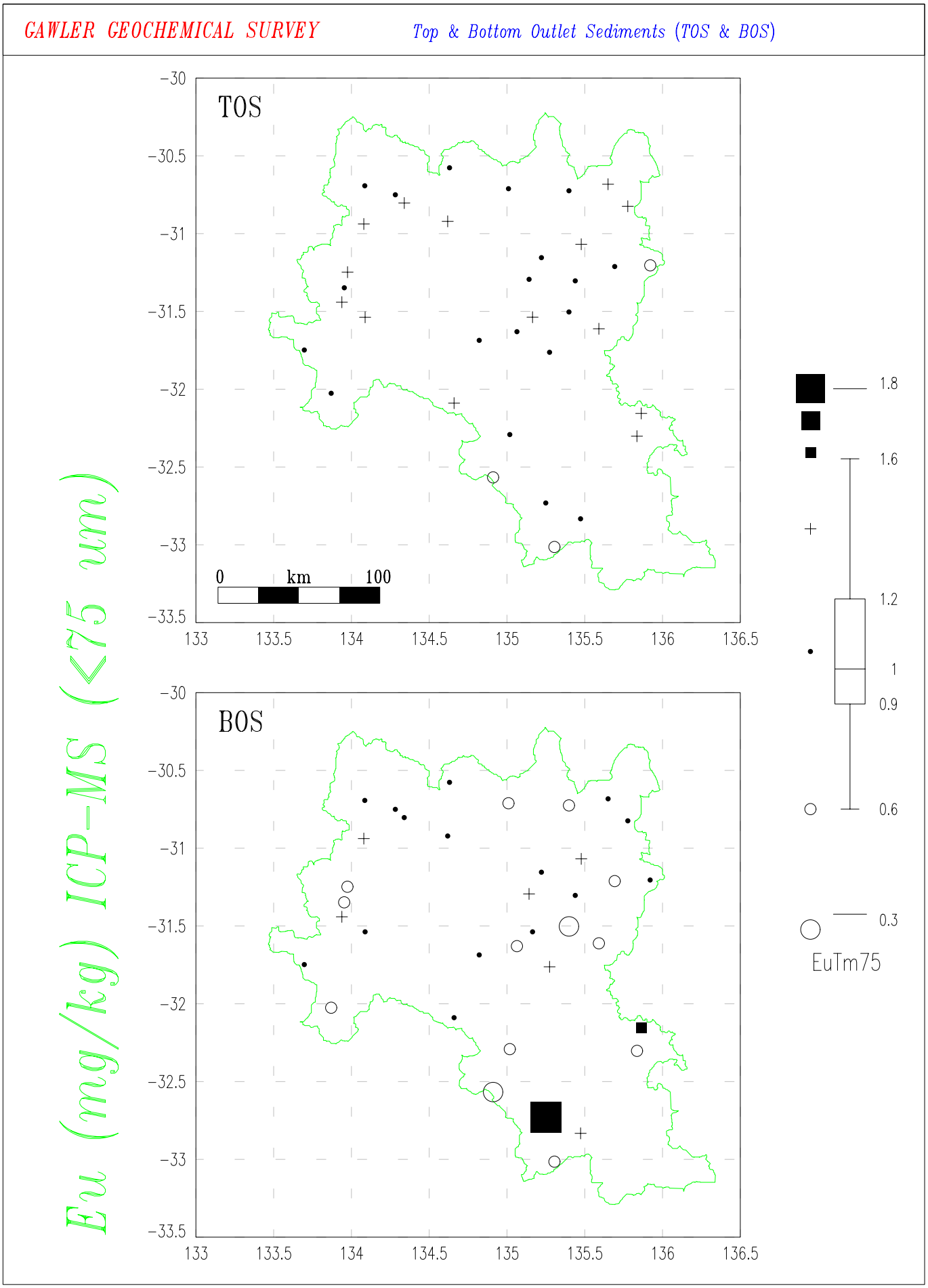
Top & Bottom Outlet Sediments (TOS & BOS)



GAWLER GEOCHEMICAL SURVEY

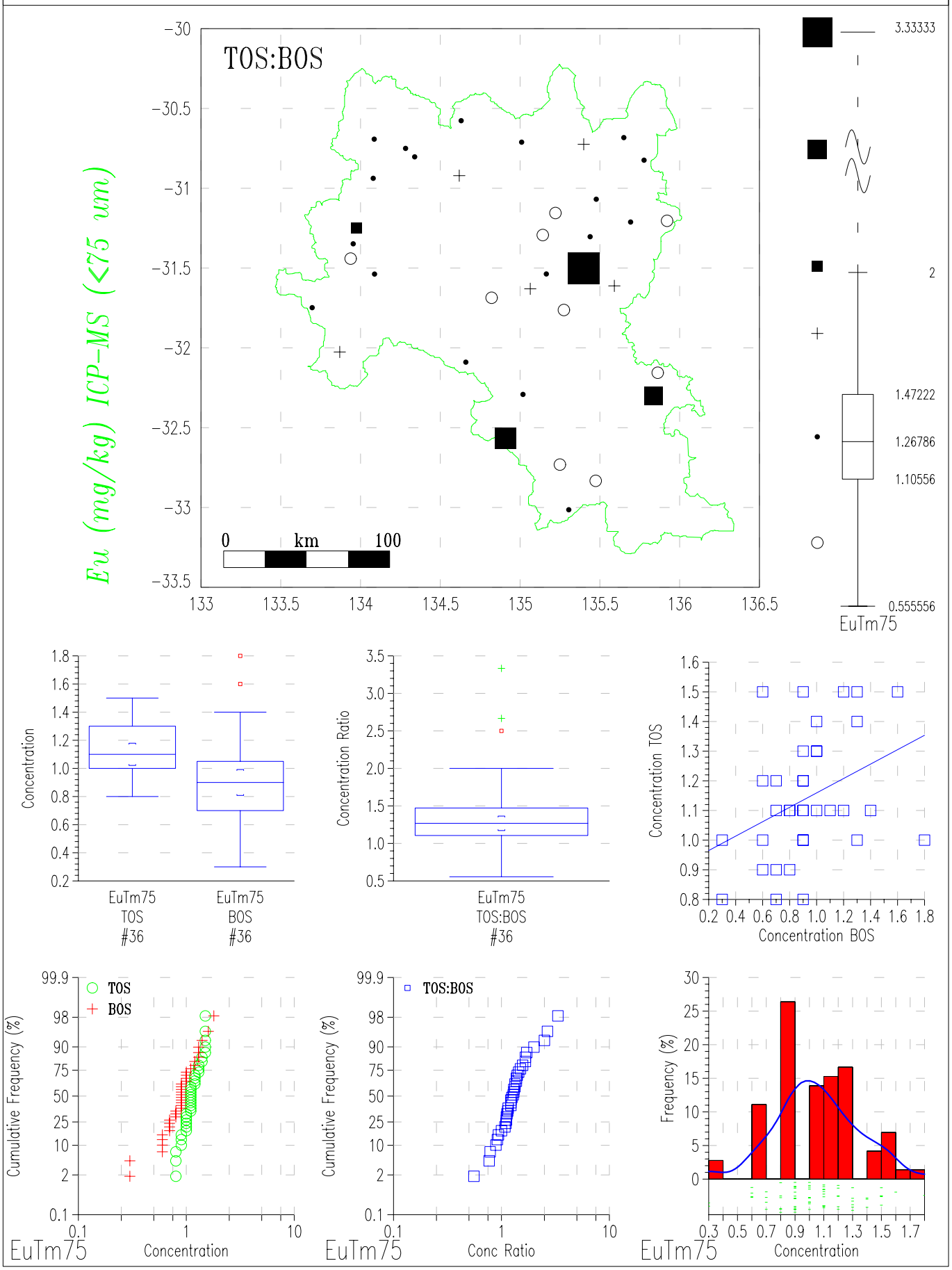
Top & Bottom Outlet Sediments (TOS & BOS)




GAWLER GEOCHEMICAL SURVEY
Top & Bottom Outlet Sediments (TOS & BOS)
Eu (mg/kg) ICP-MS (<75 um)
TOS
BOS
0 km 100
-30
-30.5
-31
-31.5
-32
-32.5
-33
-33.5
133
133.5
134
134.5
135
135.5
136
136.5
1.8
1.6
1.2
1
0.9
0.6
0.3
EuTm75

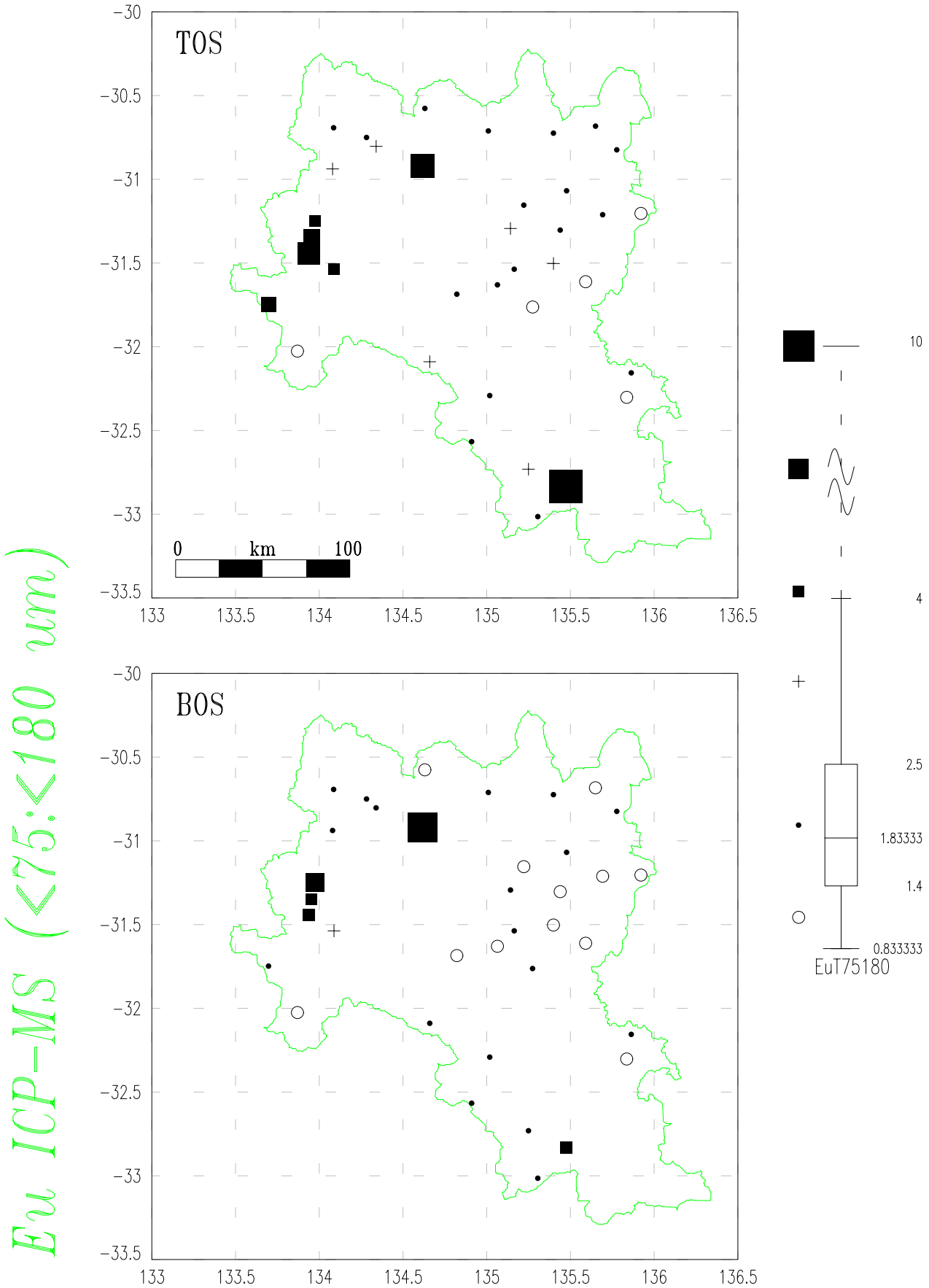
GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



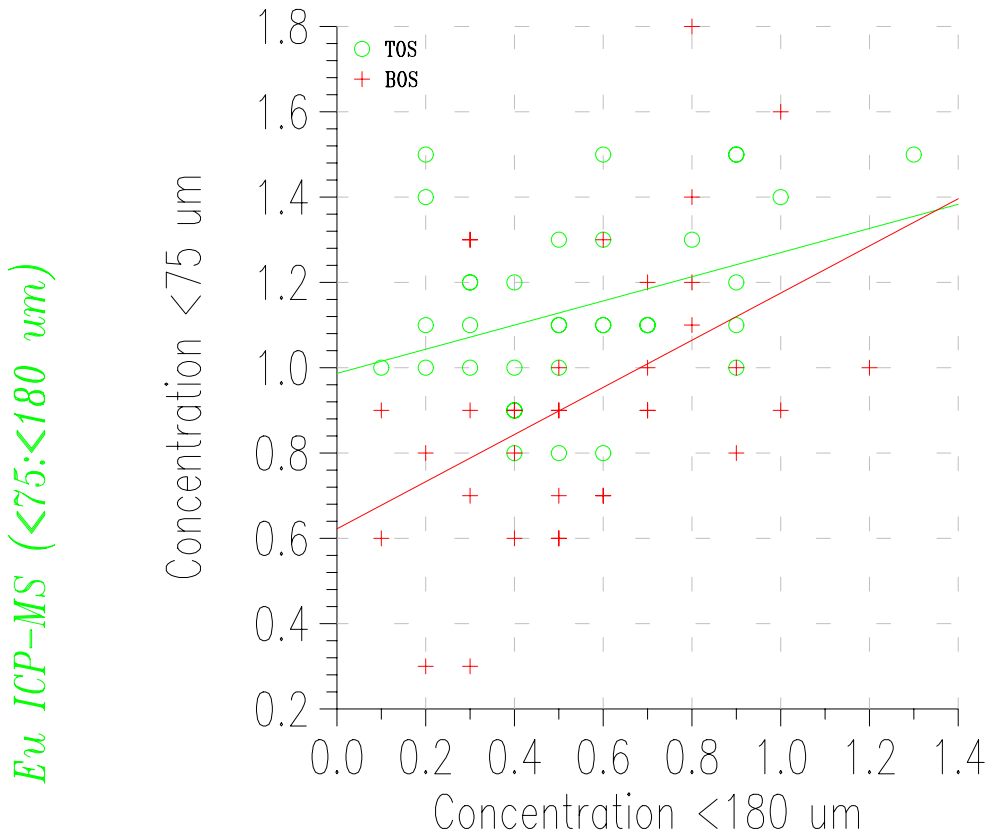
GAWLER GEOCHEMICAL SURVEY

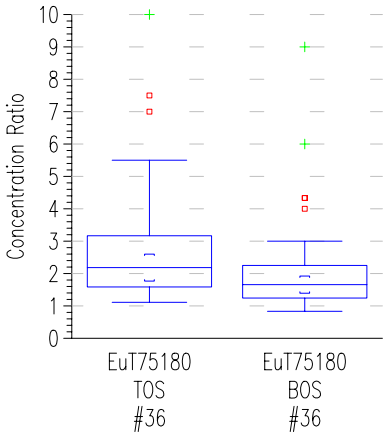
Top & Bottom Outlet Sediments (TOS & BOS)

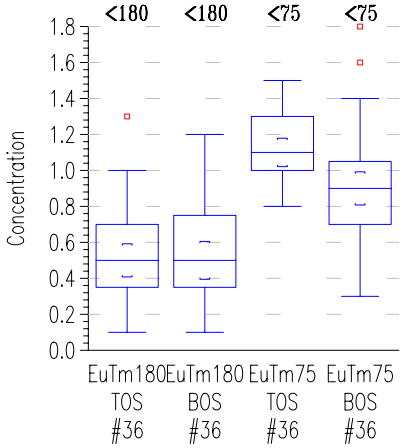


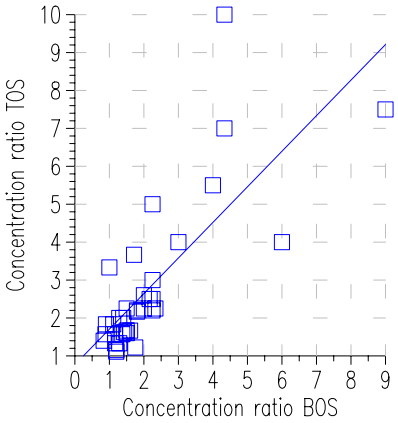
GAWLER GEOCHEMICAL SURVEY

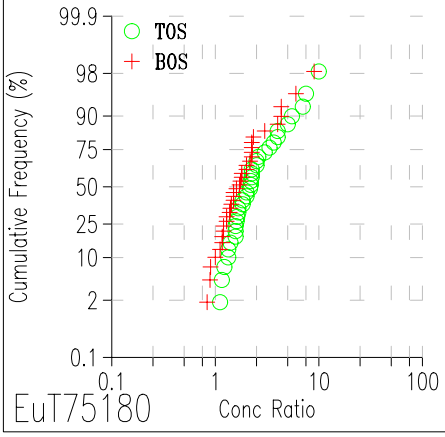
Top & Bottom Outlet Sediments (TOS & BOS)

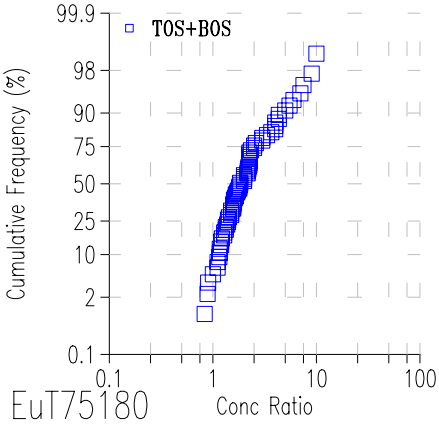


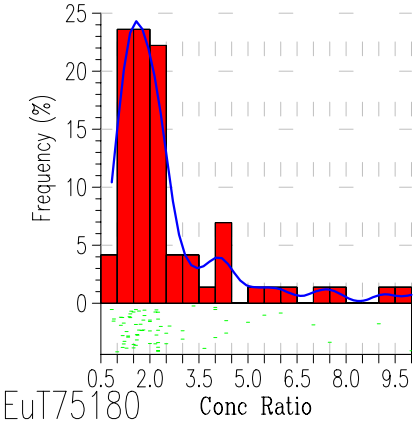






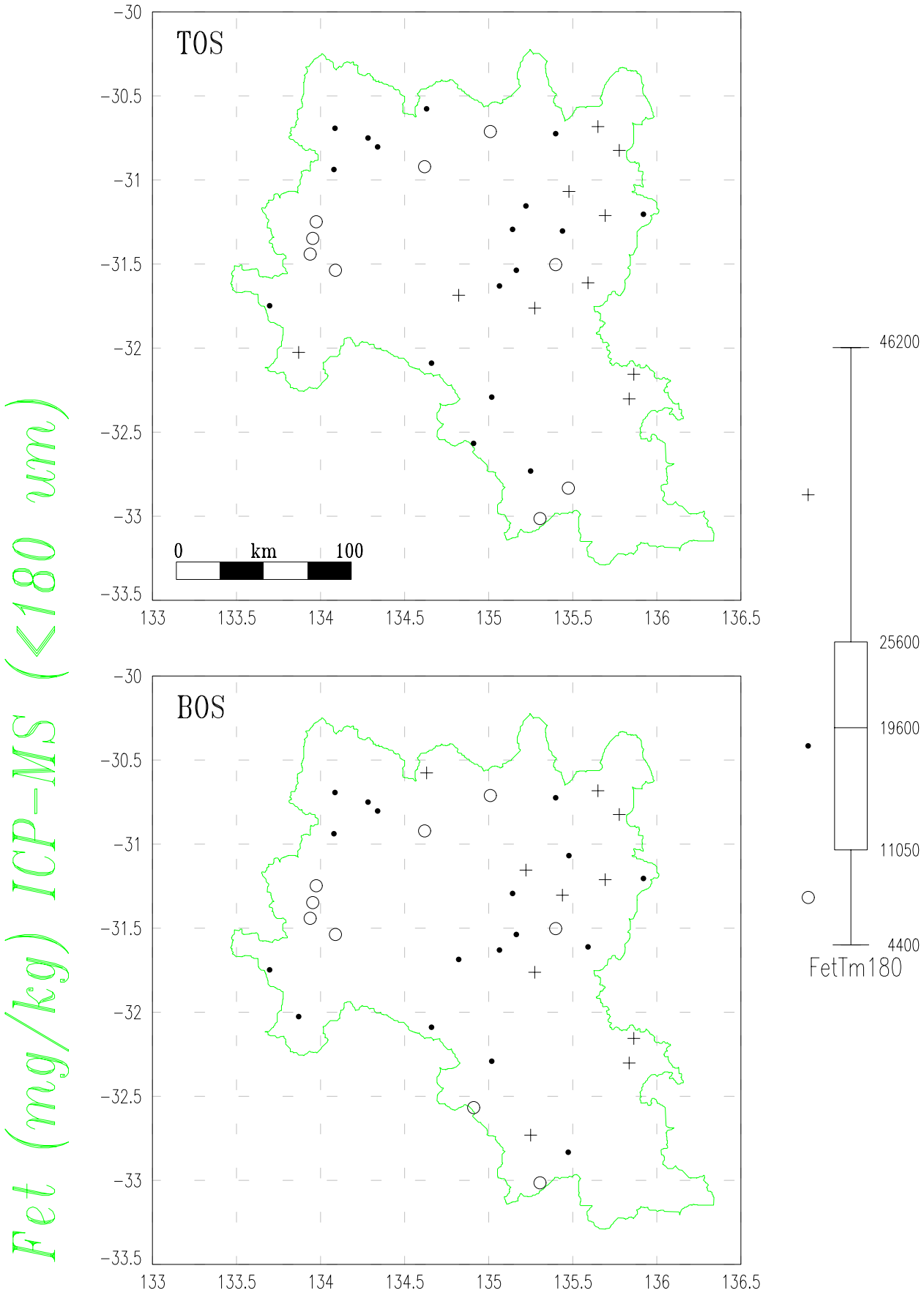






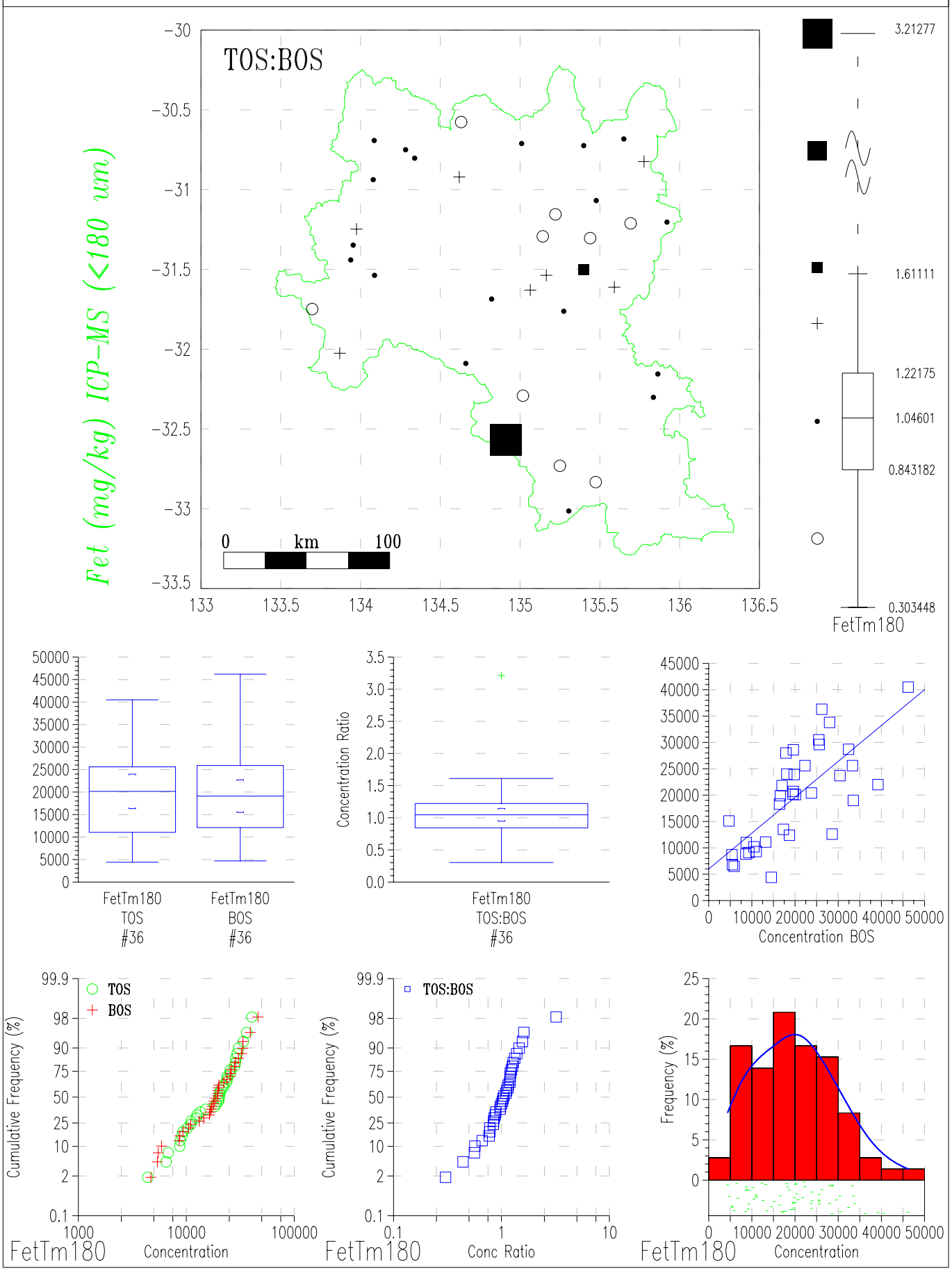
GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



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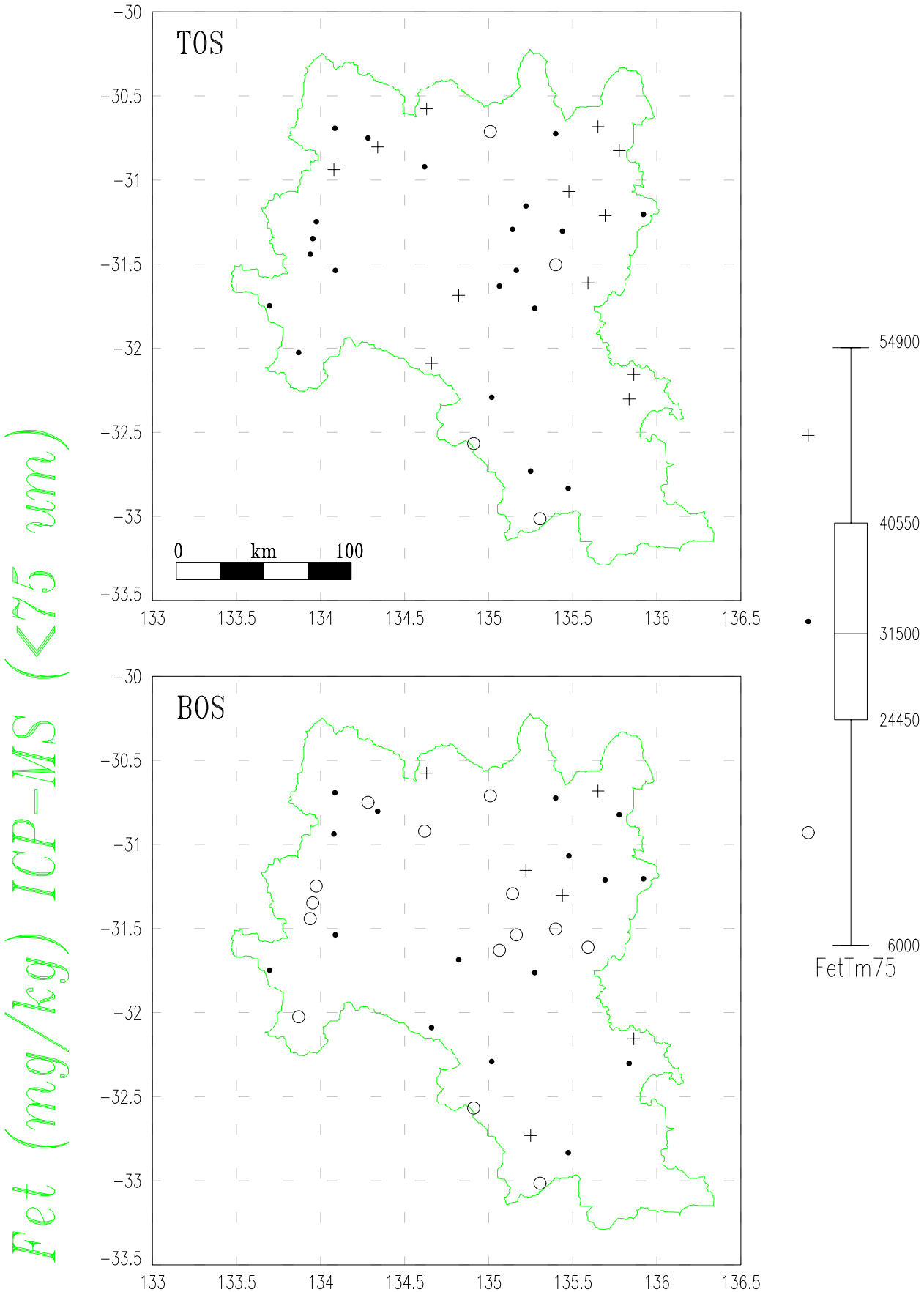
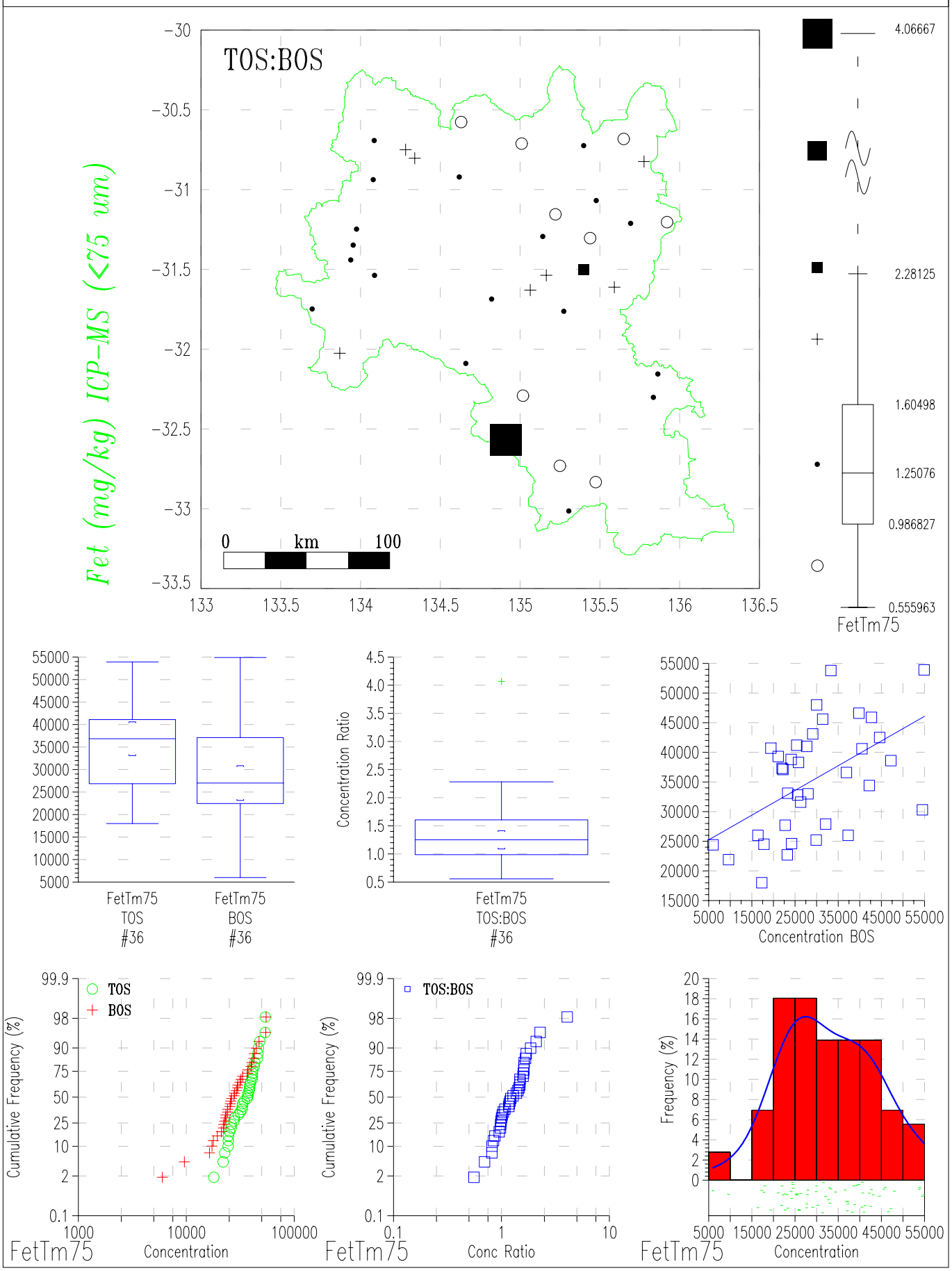
Top & Bottom Outlet Sediments (TOS & BOS)



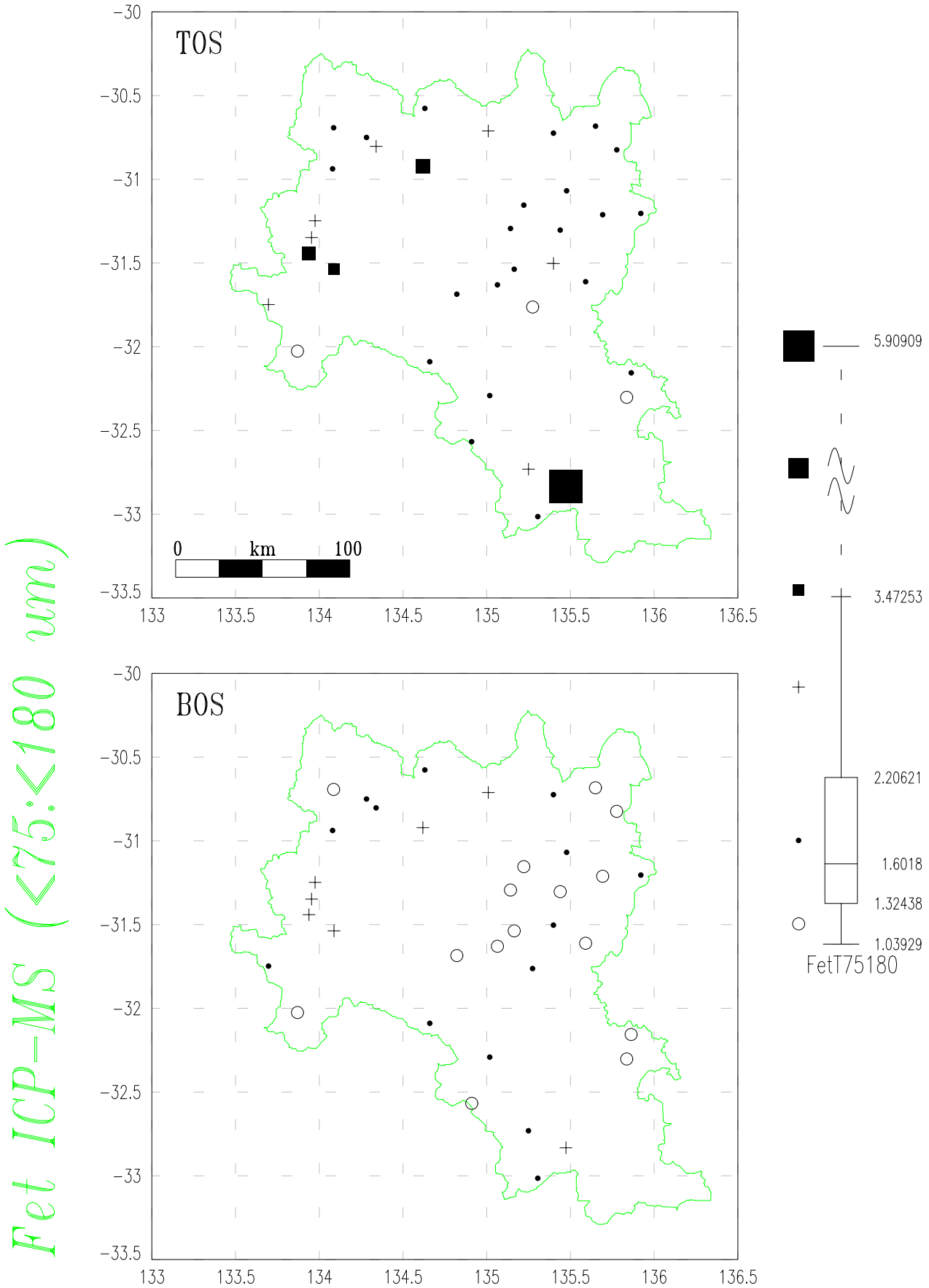
GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



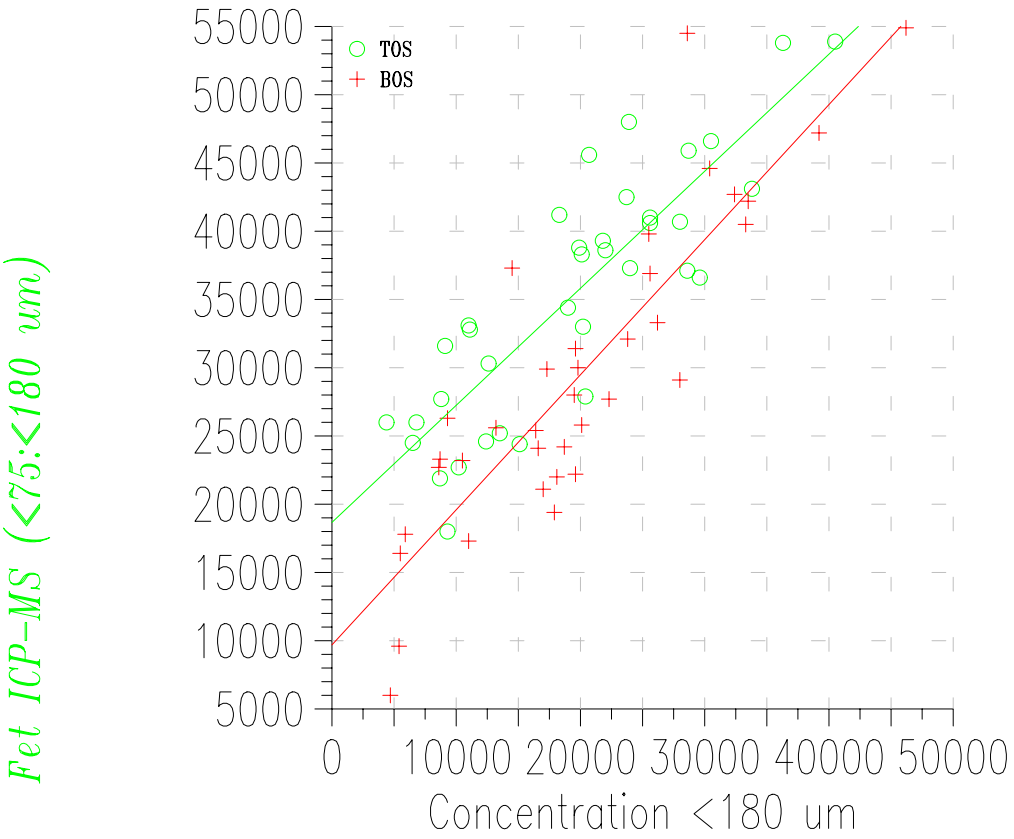
GAWLER GEOCHEMICAL SURVEY

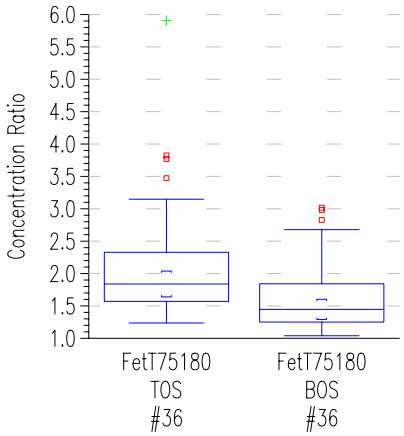
Top & Bottom Outlet Sediments (TOS & BOS)

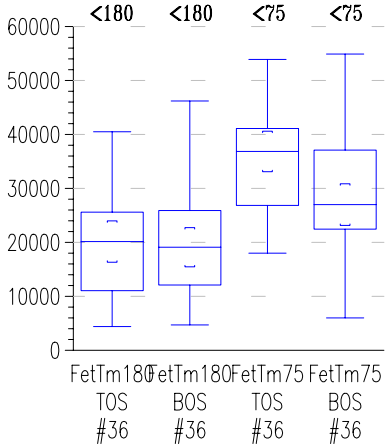


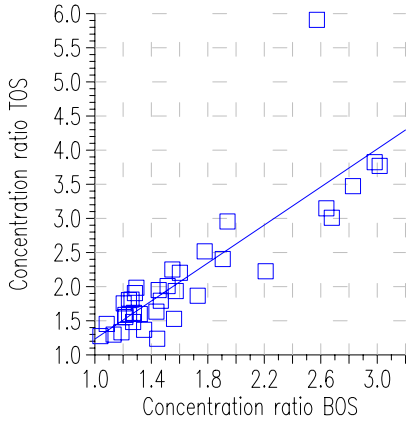
GAWLER GEOCHEMICAL SURVEY

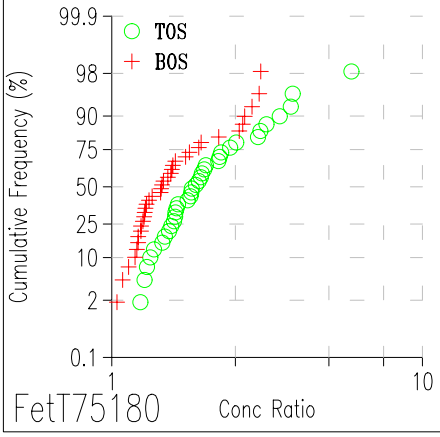
Top & Bottom Outlet Sediments (TOS & BOS)

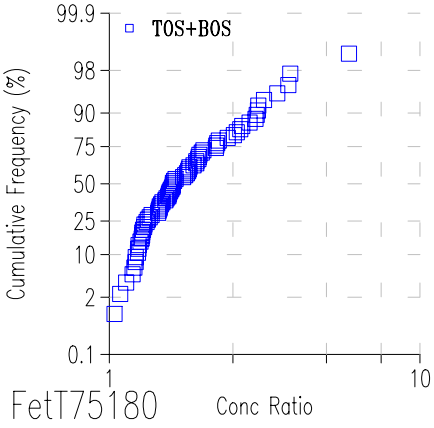


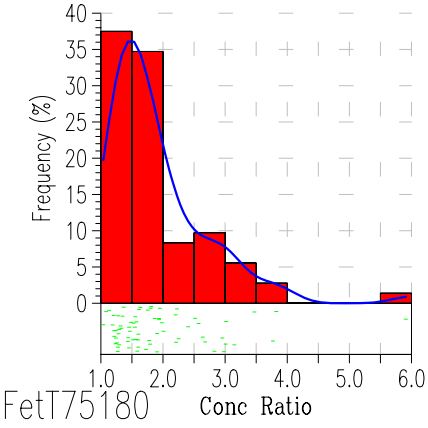






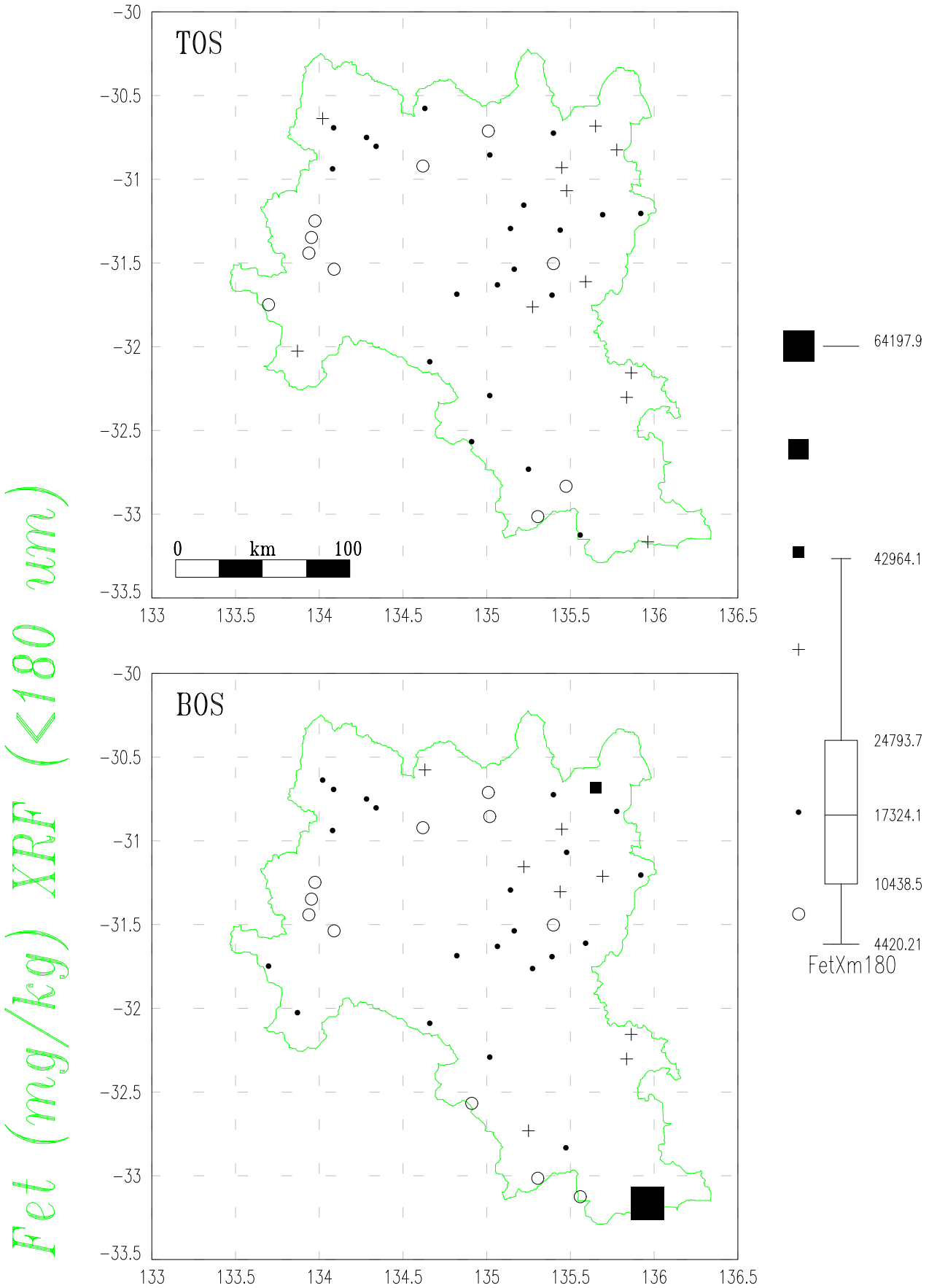






GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



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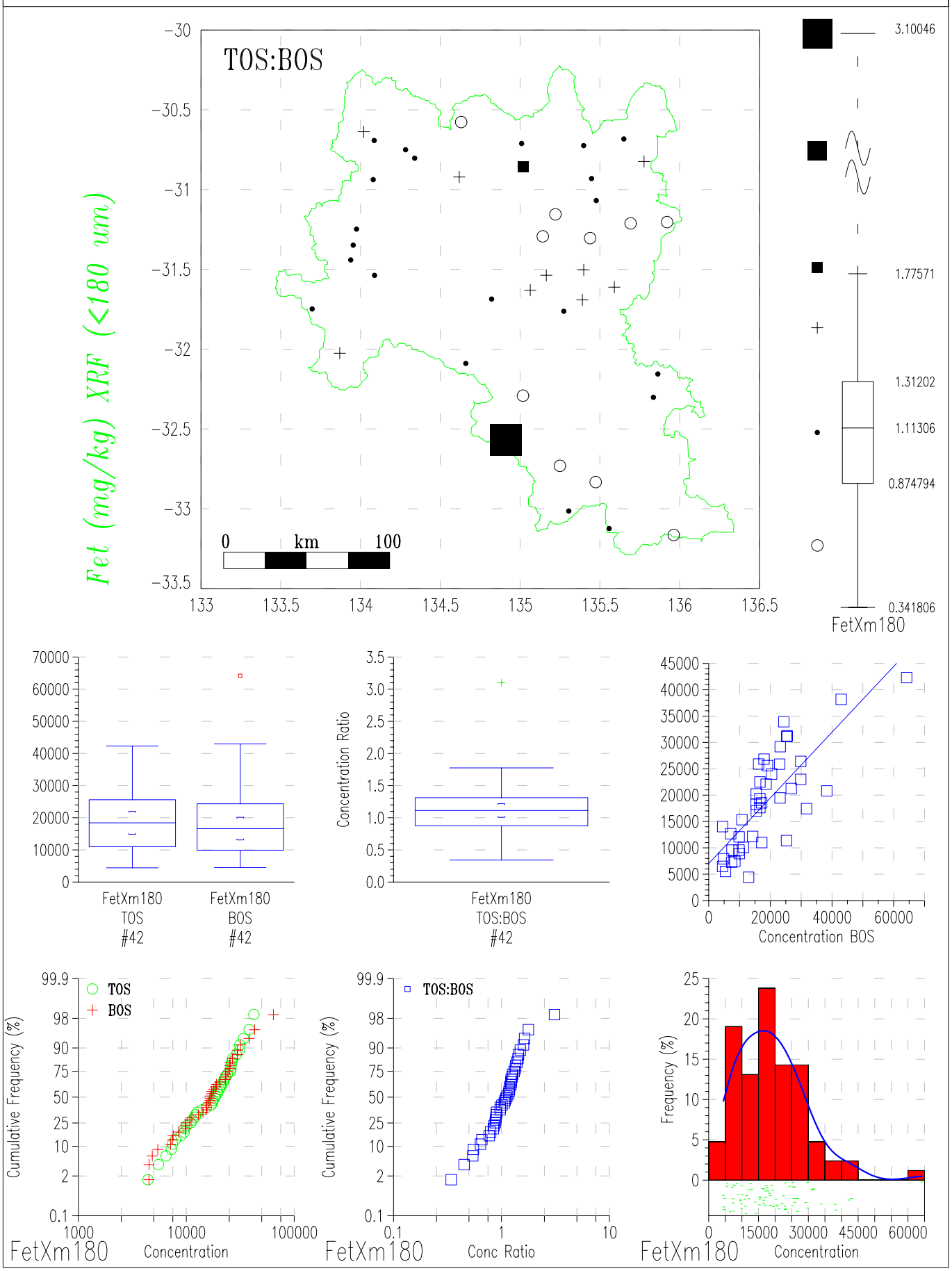
Top & Bottom Outlet Sediments (TOS & BOS)



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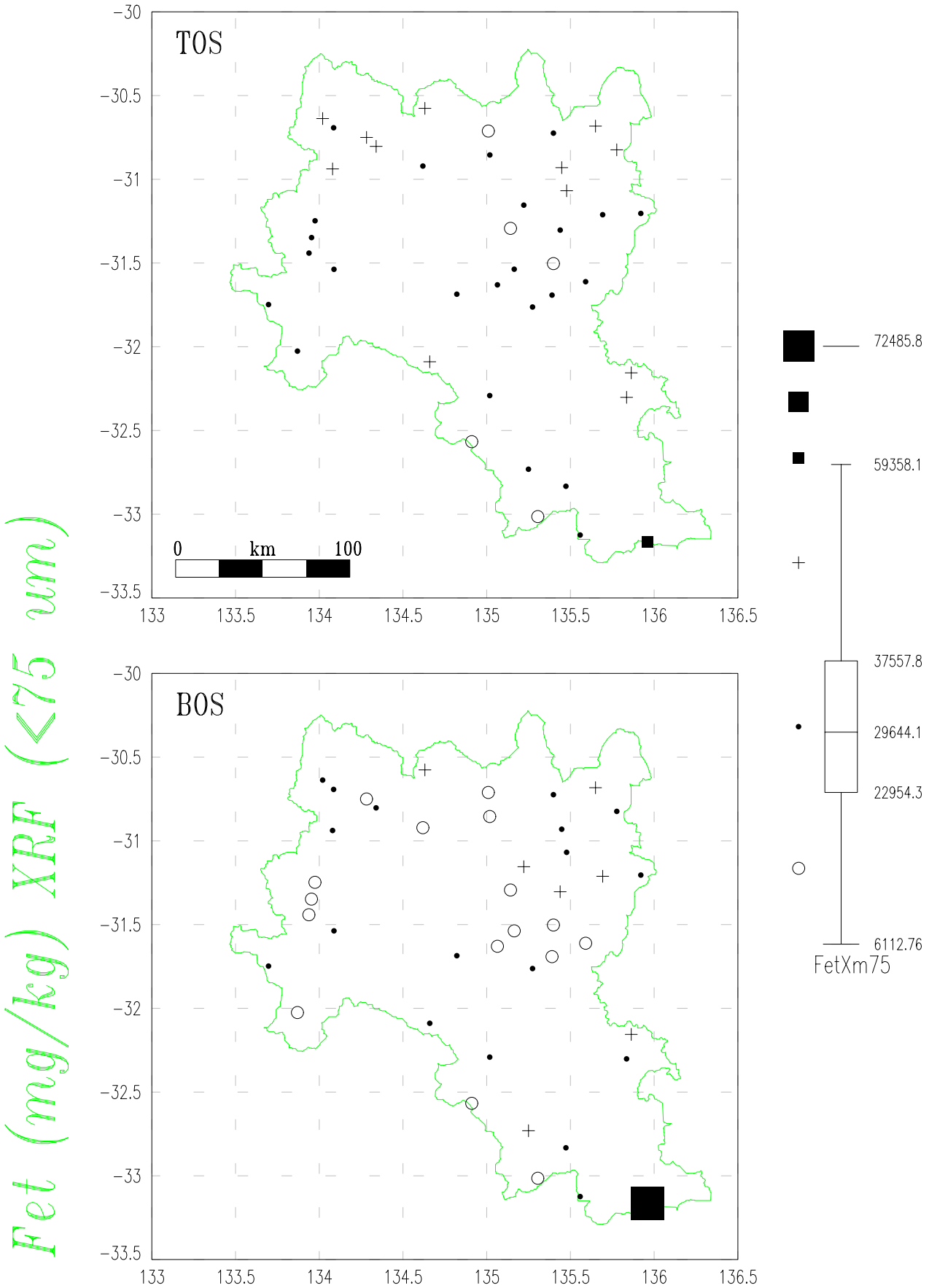

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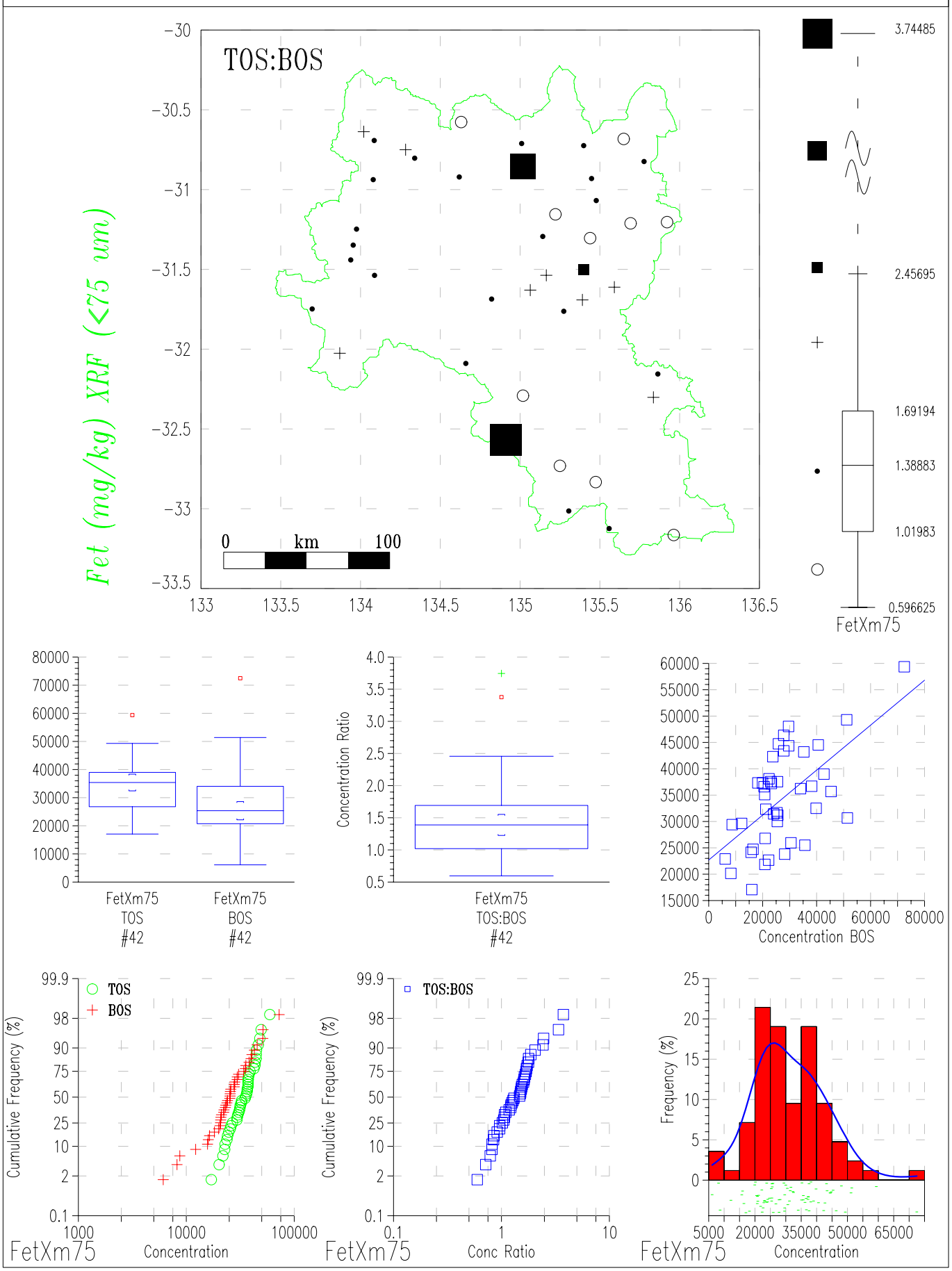

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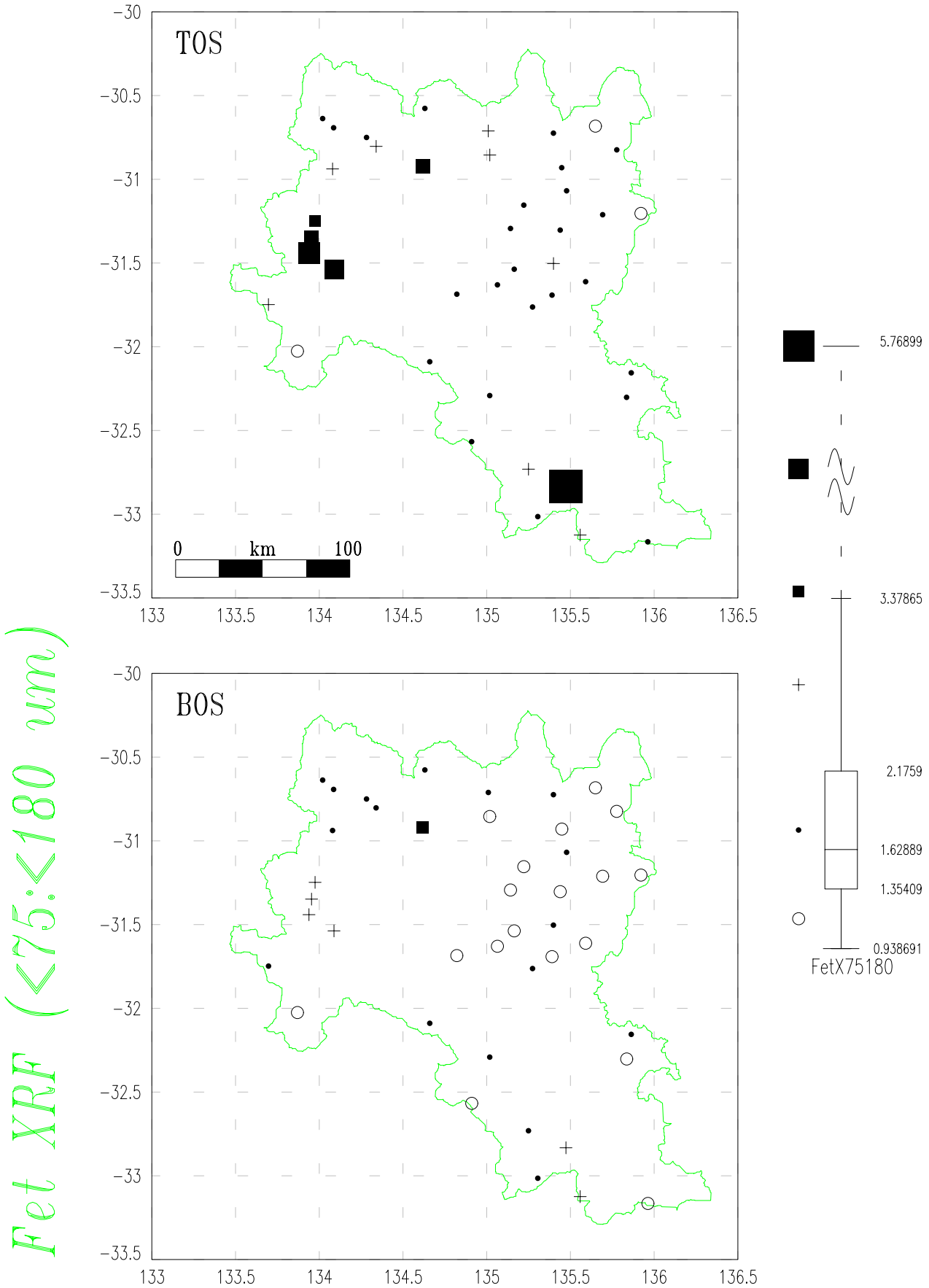

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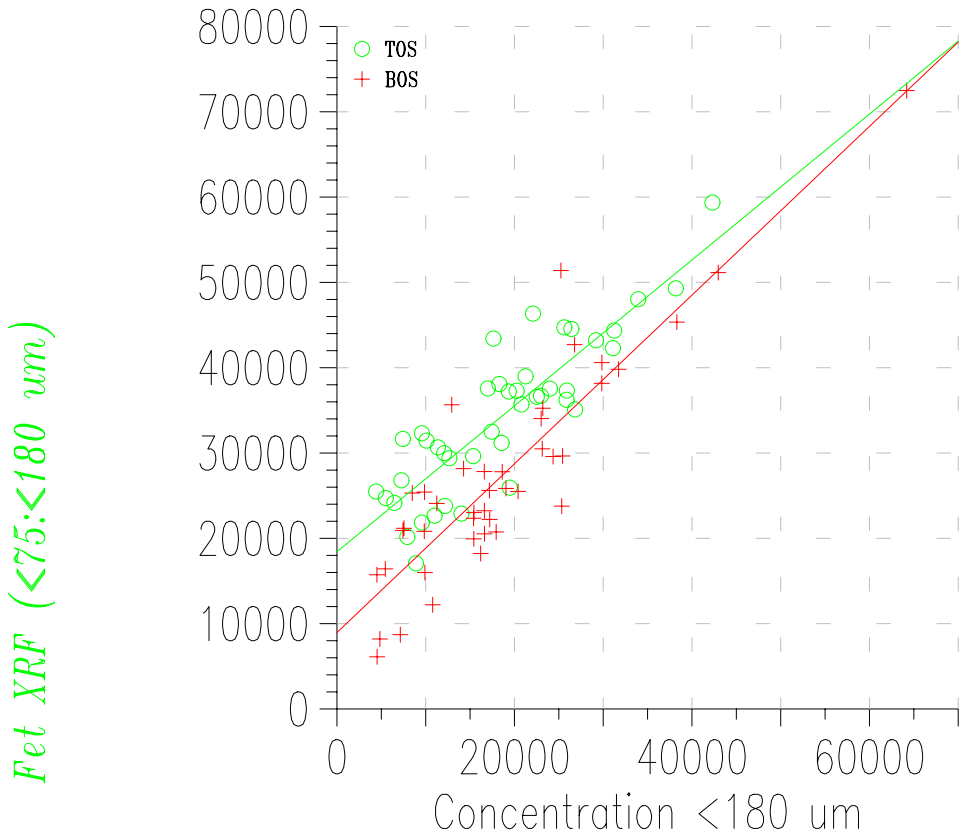
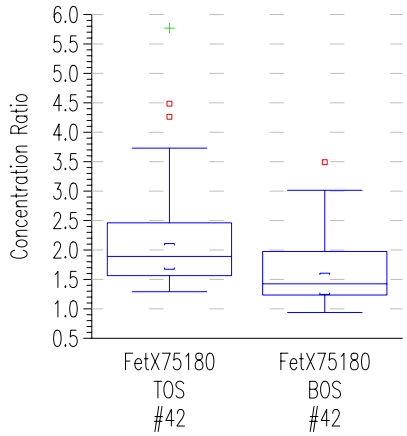
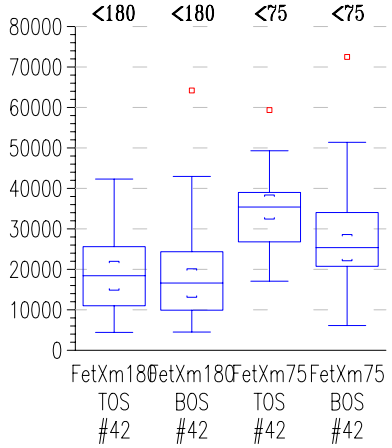
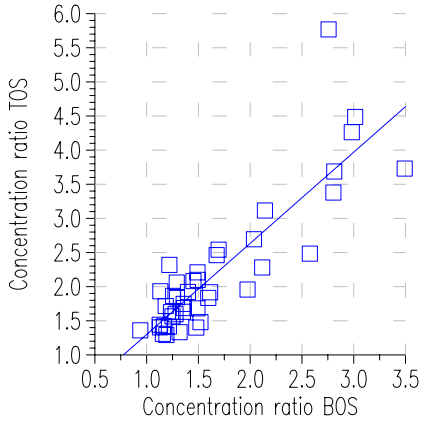
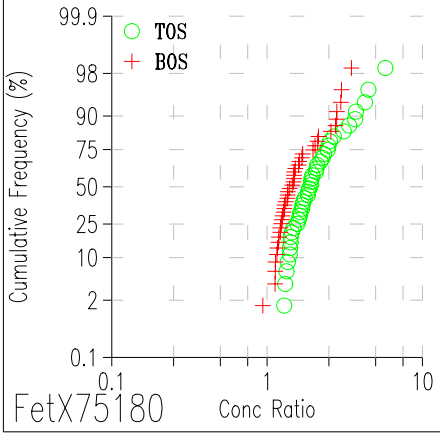
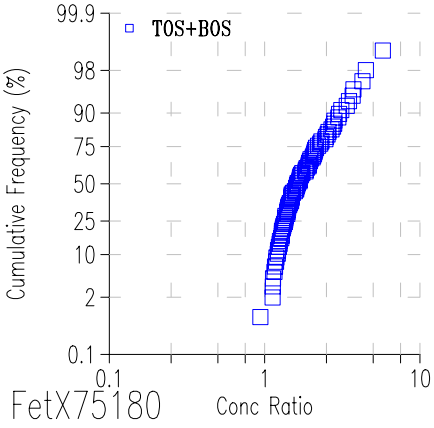


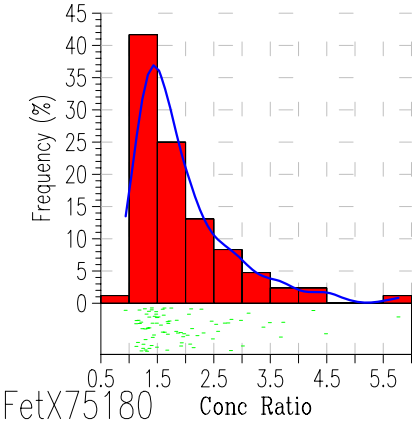






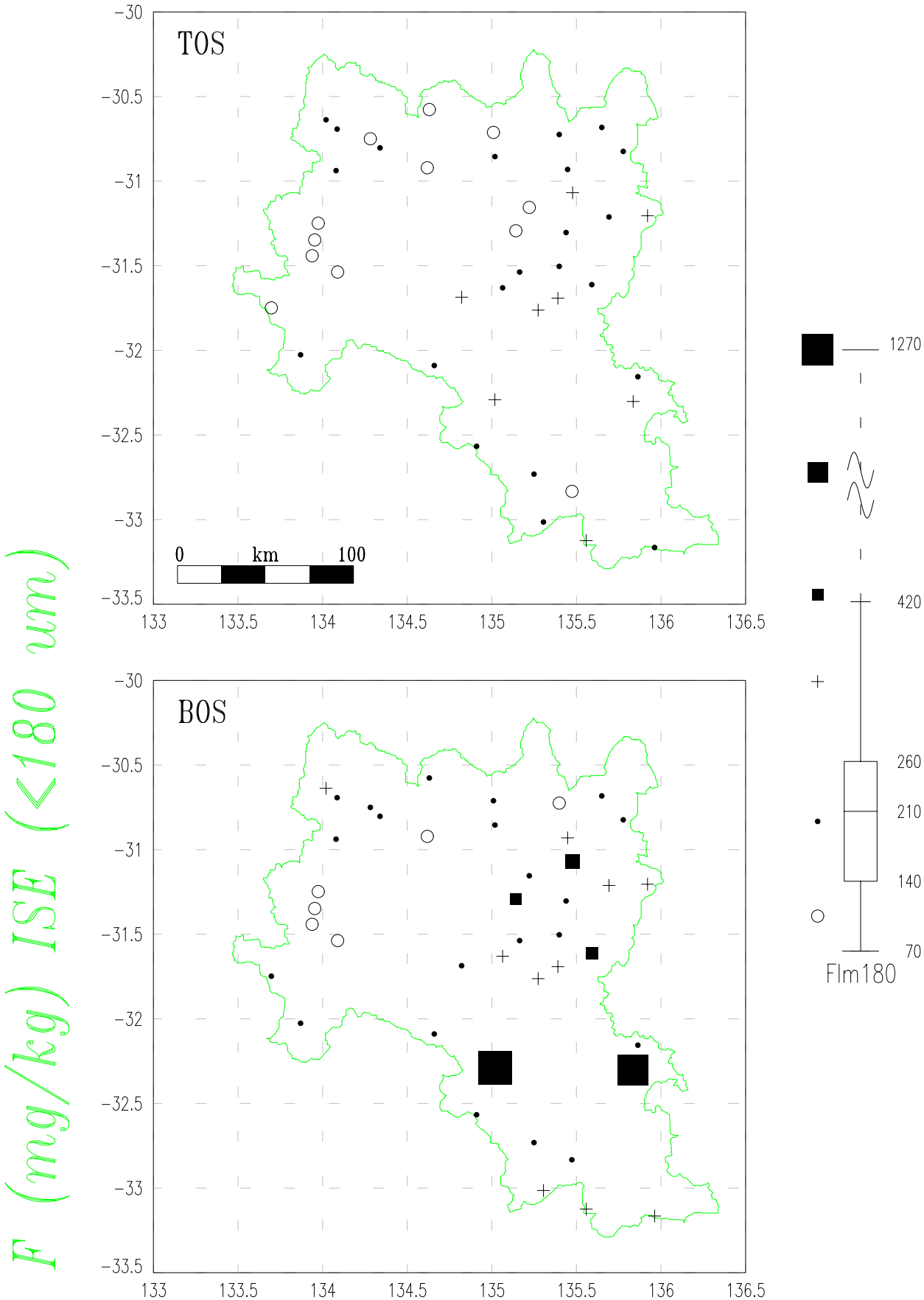






GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



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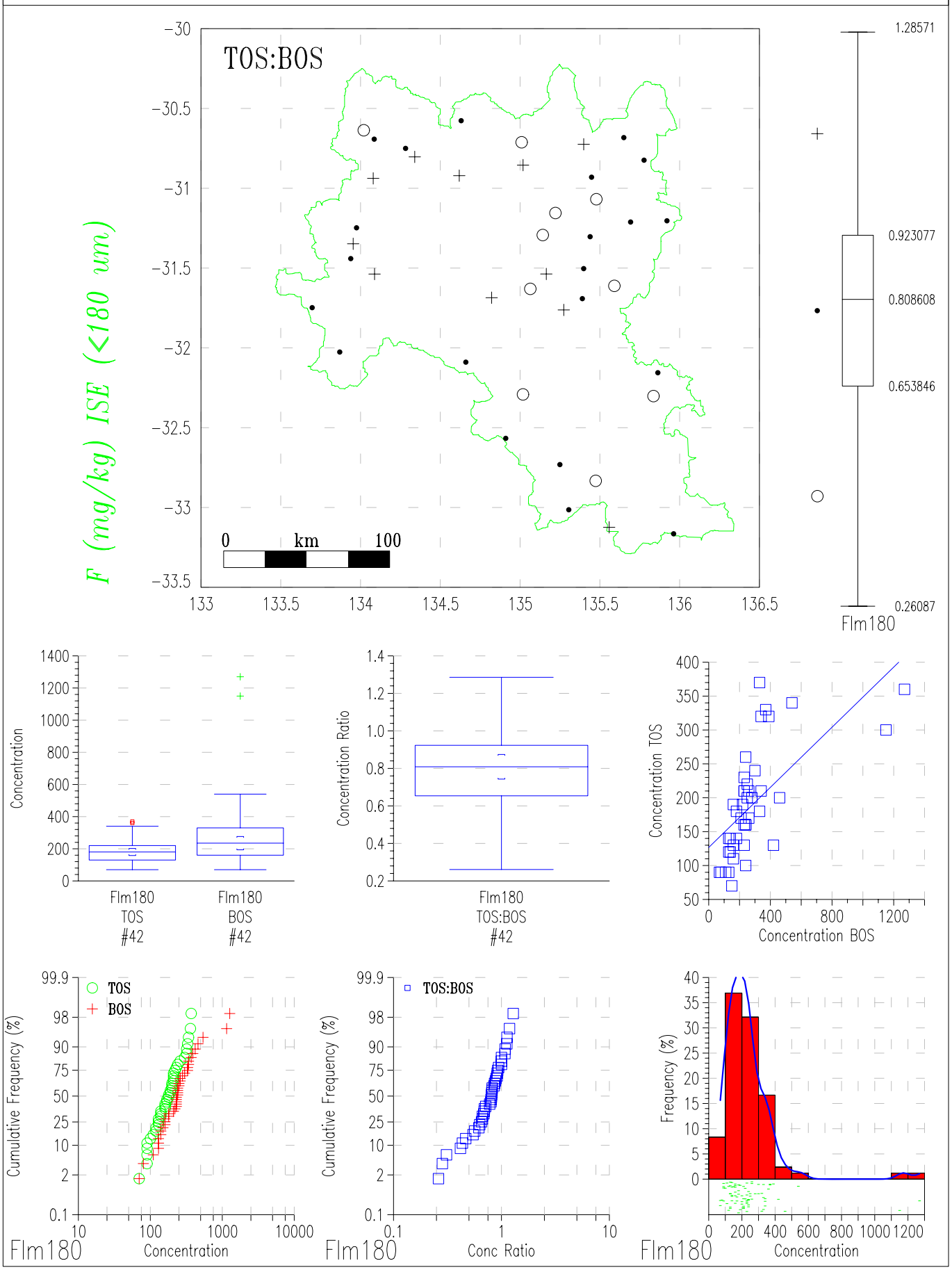

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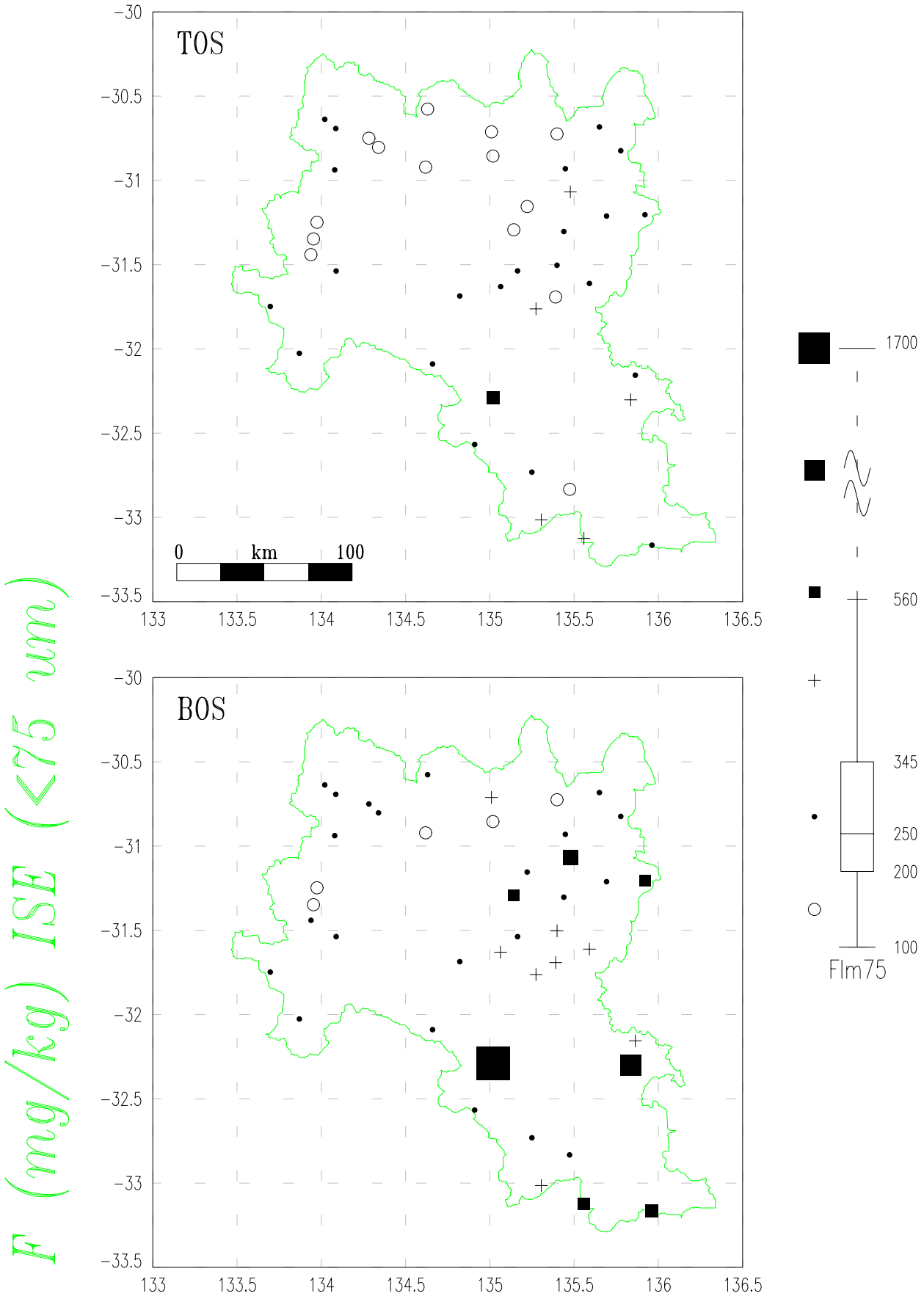

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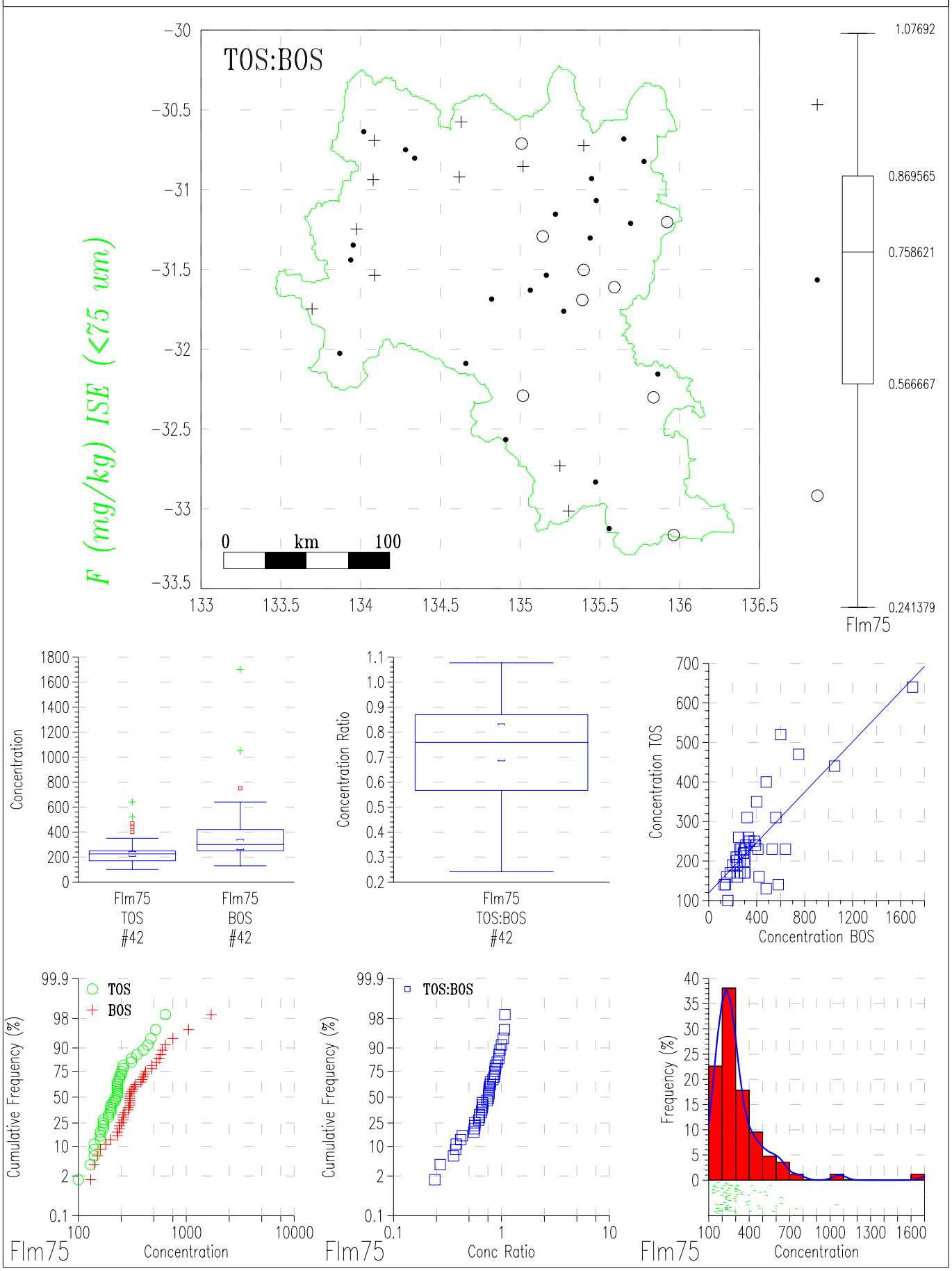

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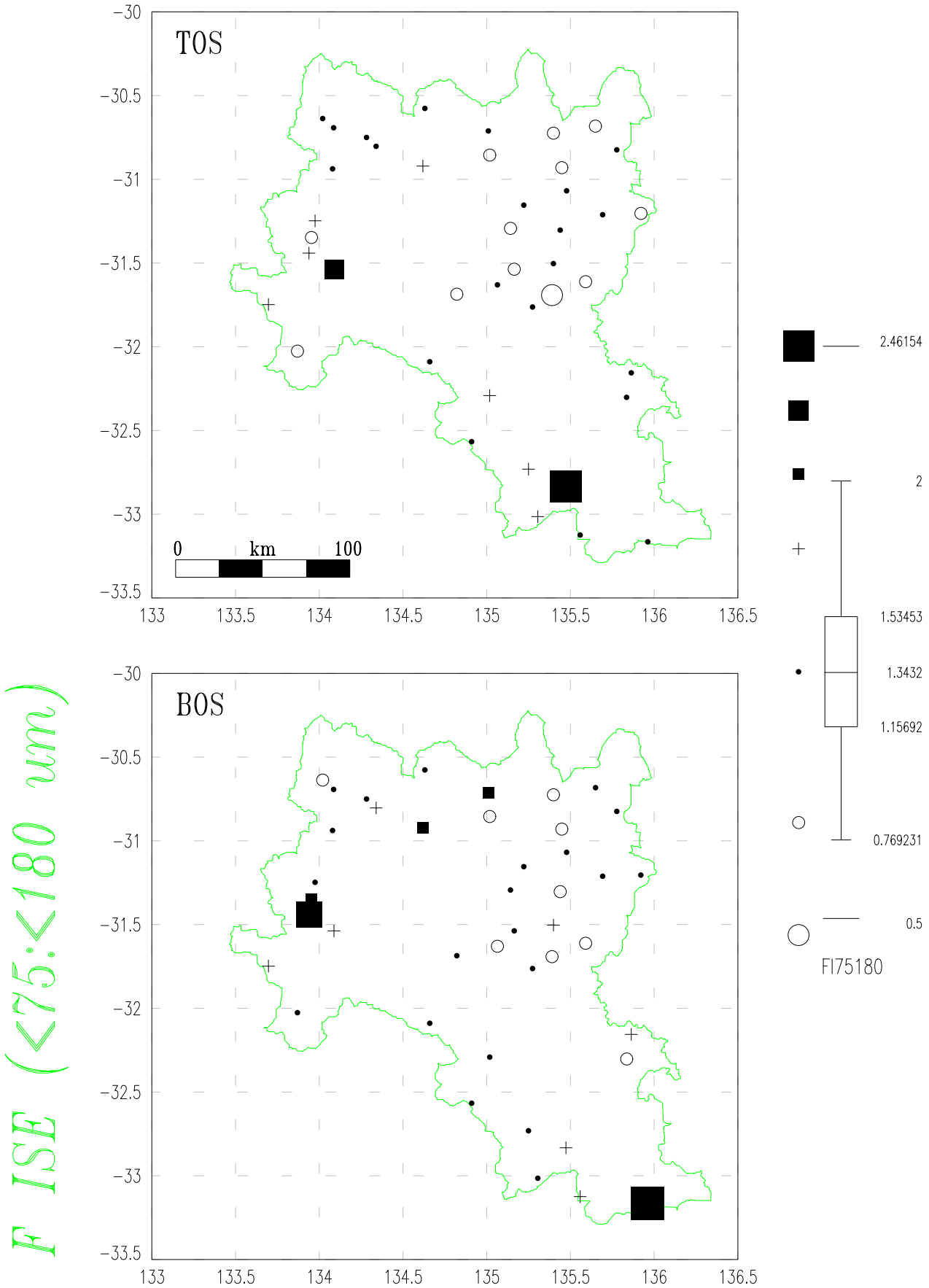

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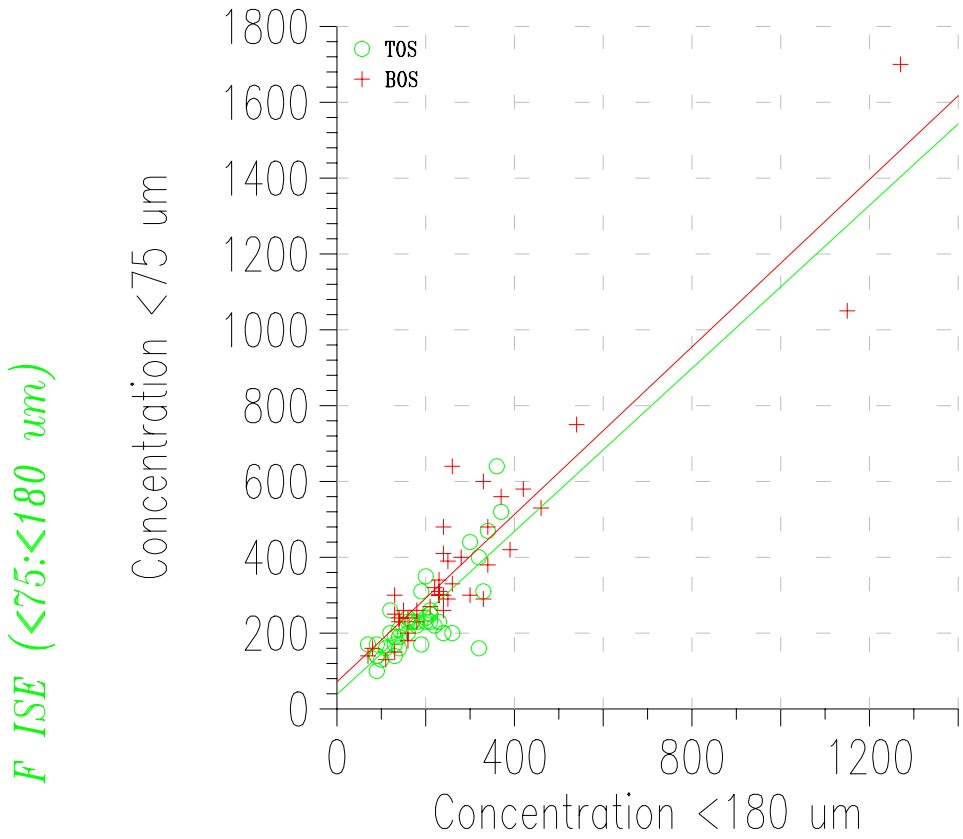
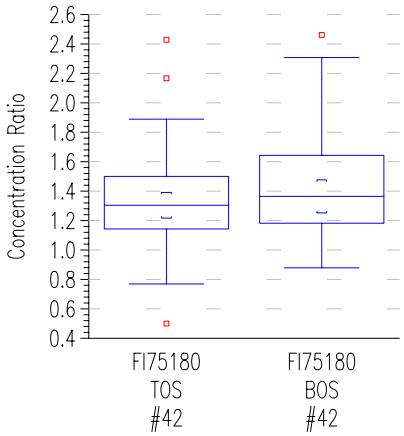
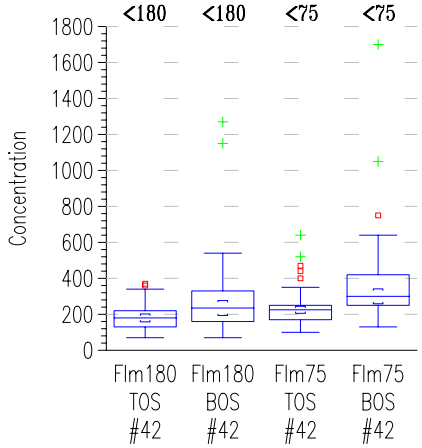
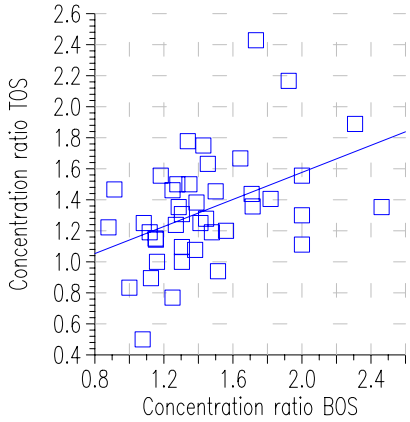
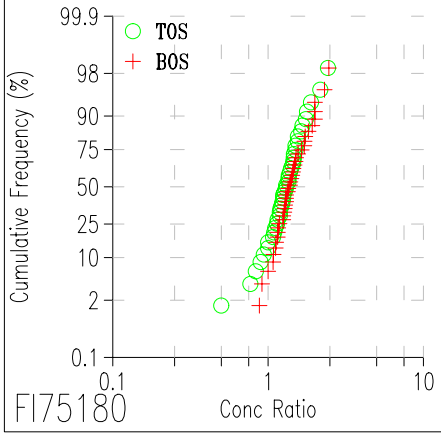
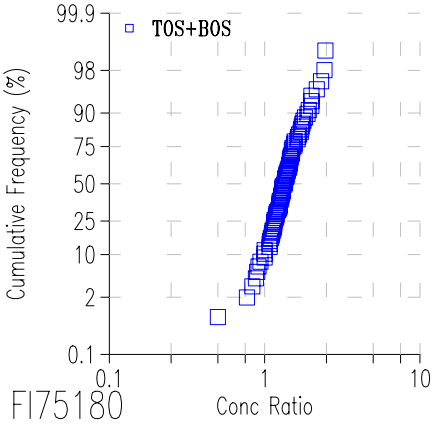


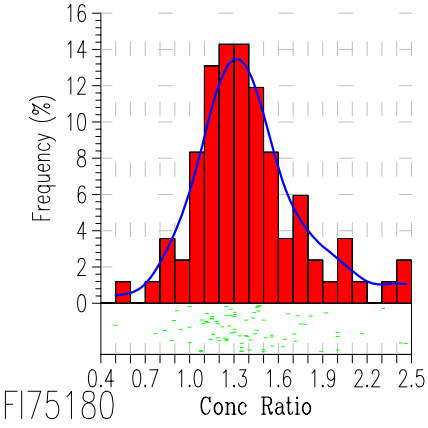






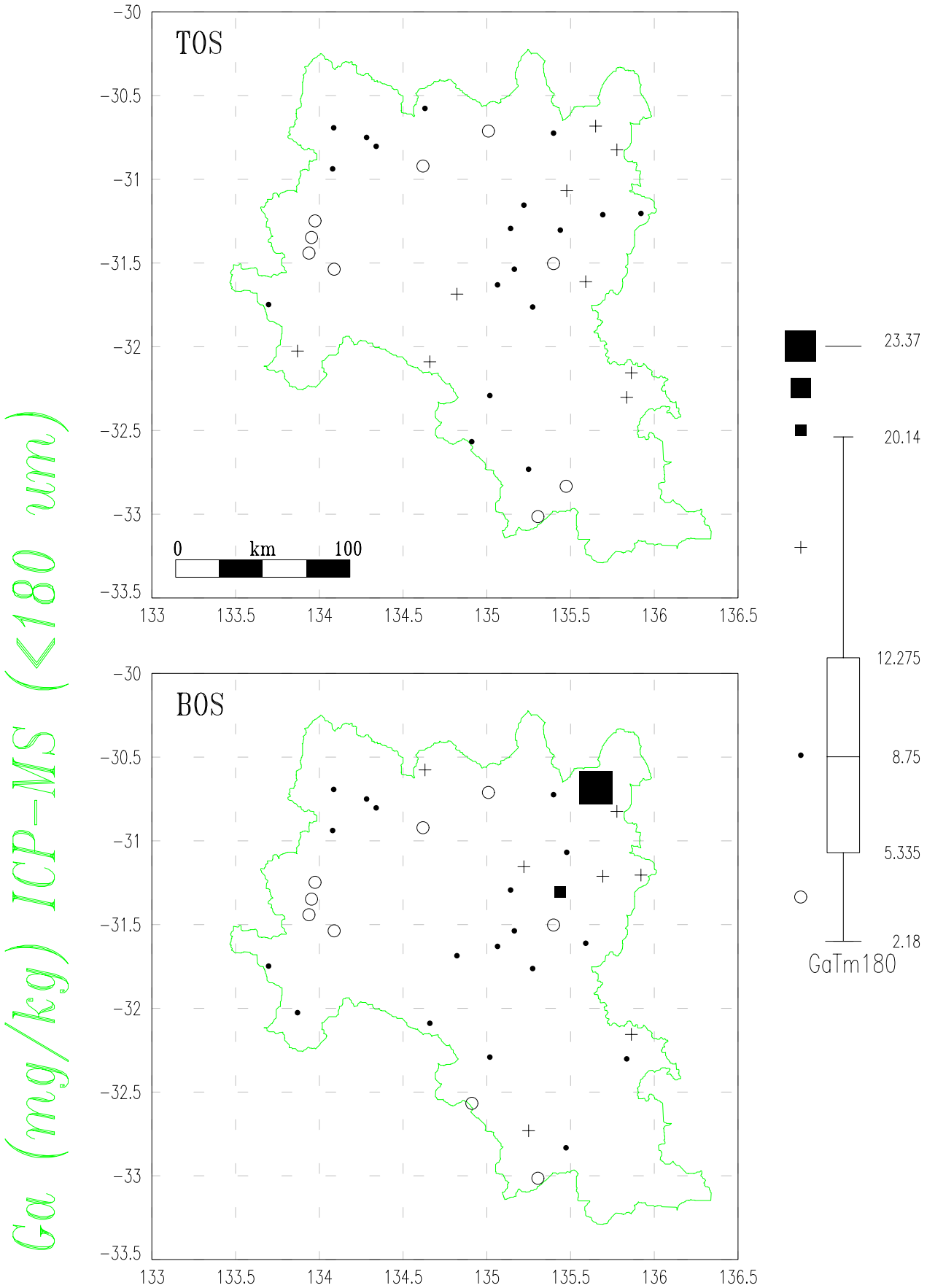






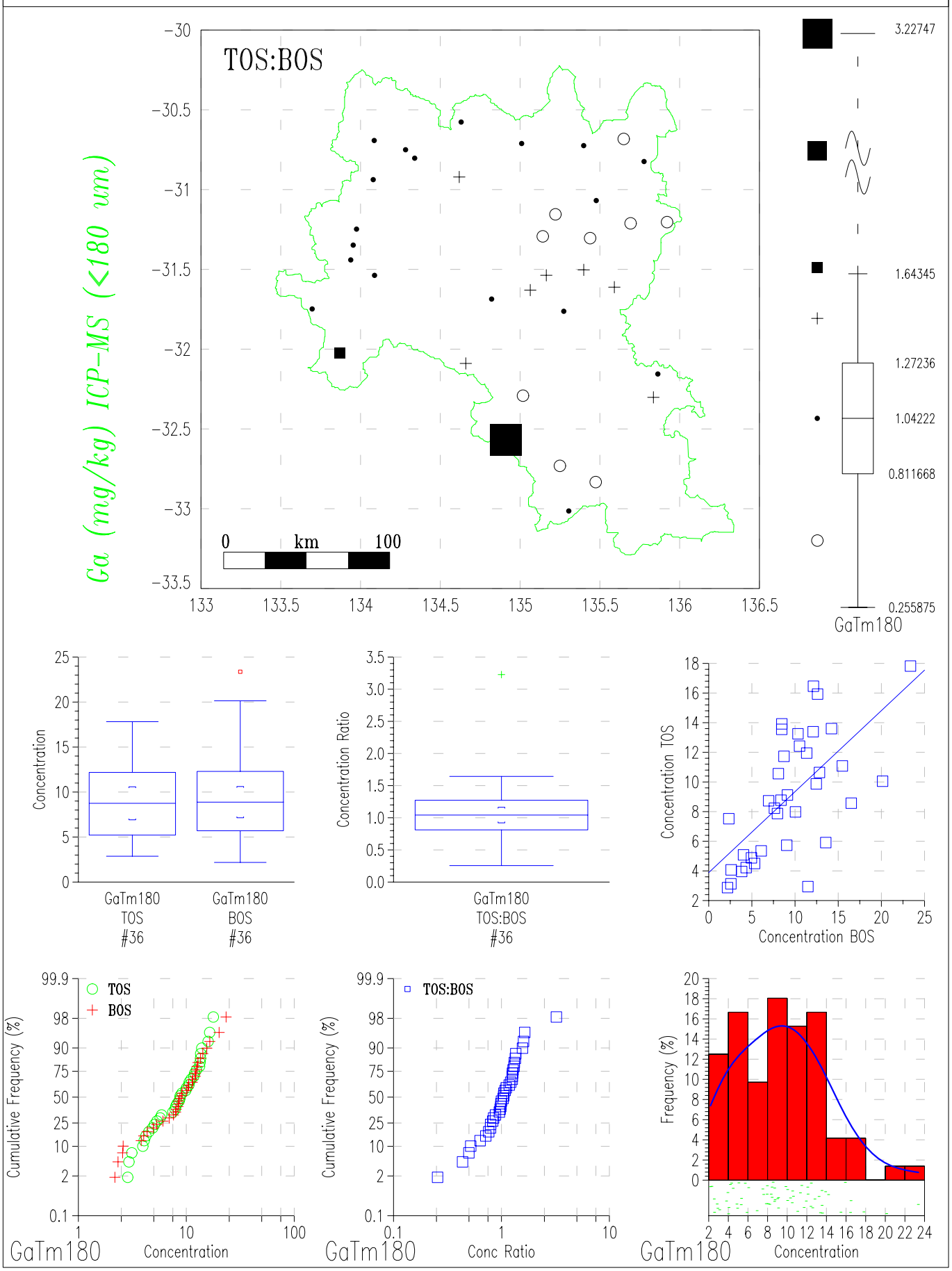
GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



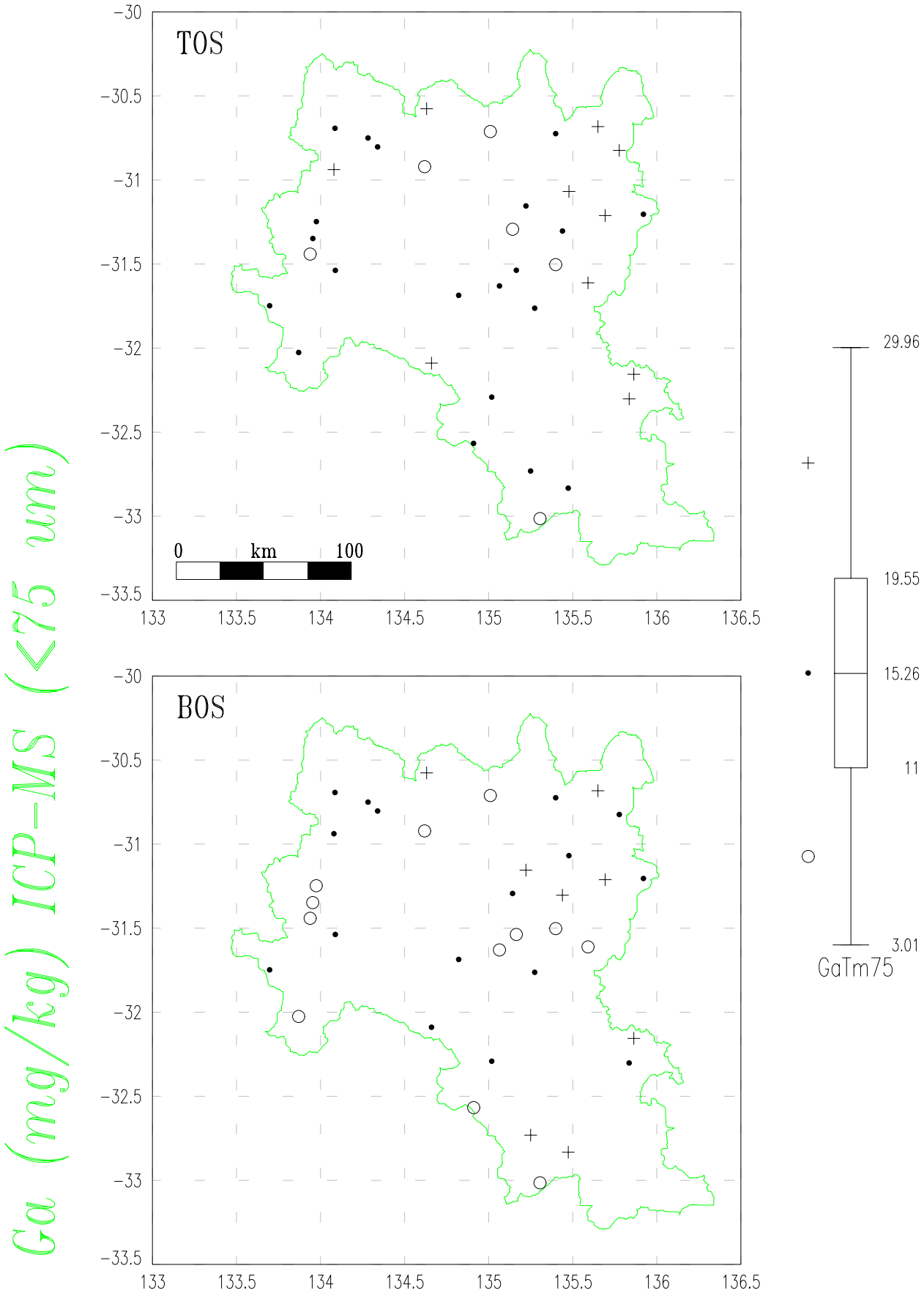
GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)



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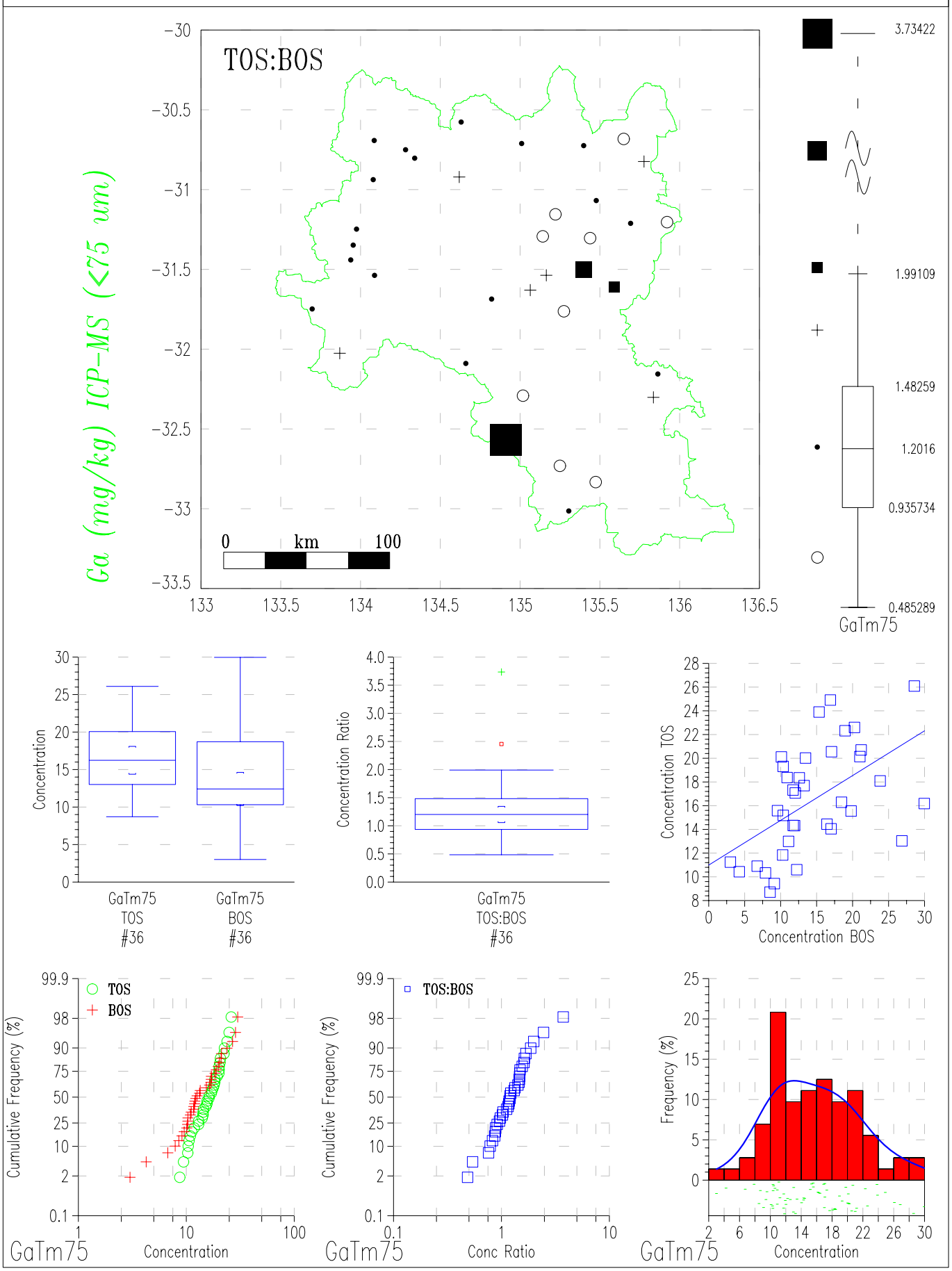
Top & Bottom Outlet Sediments (TOS & BOS)



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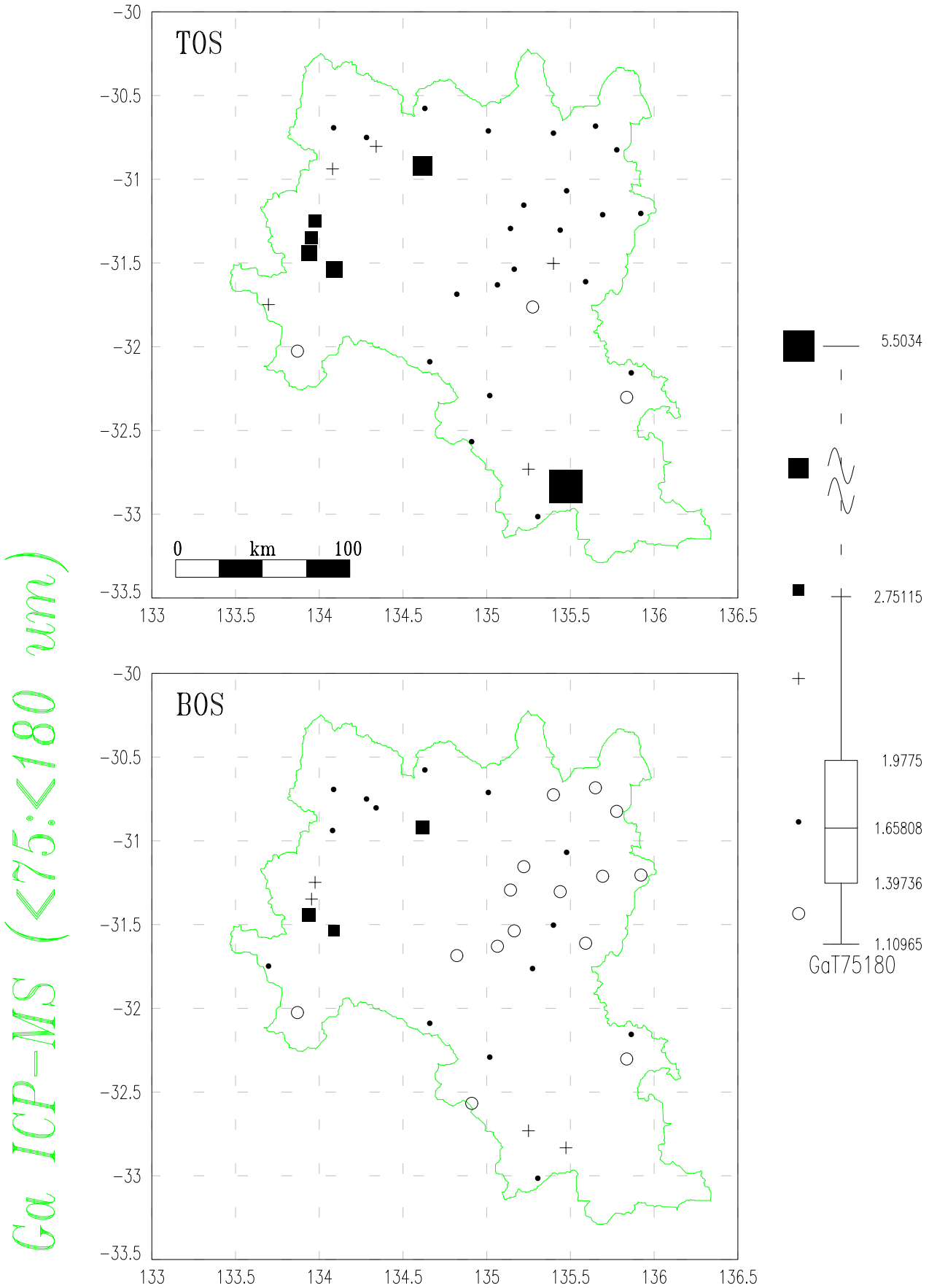
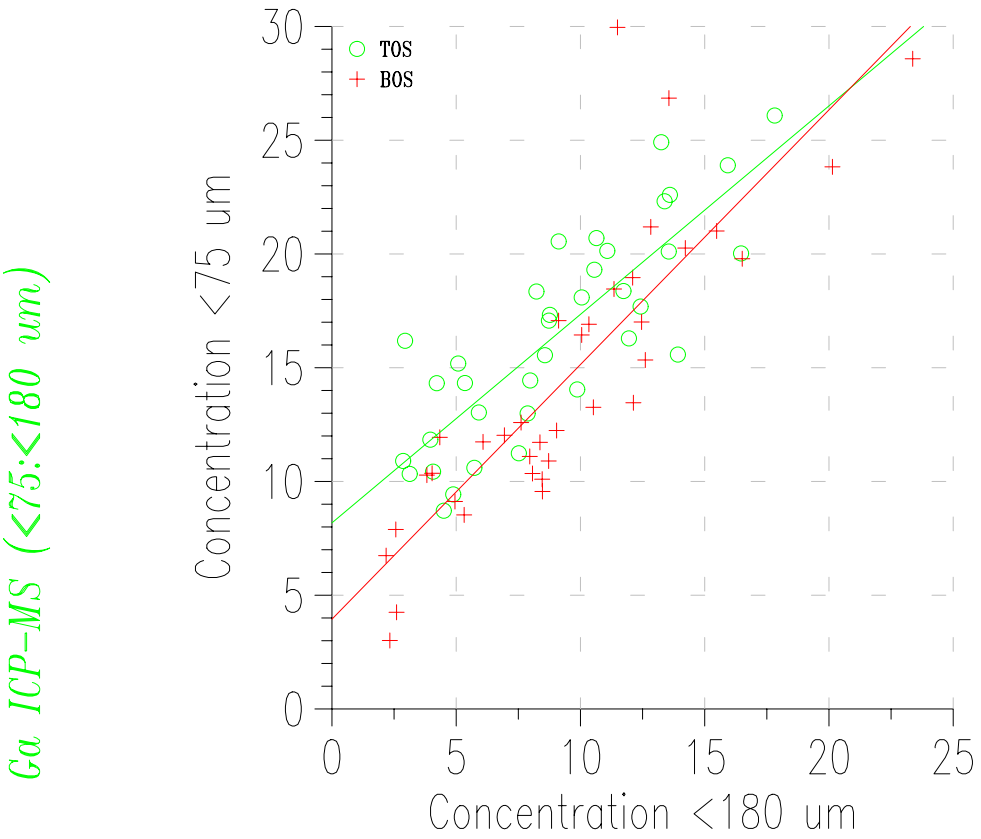
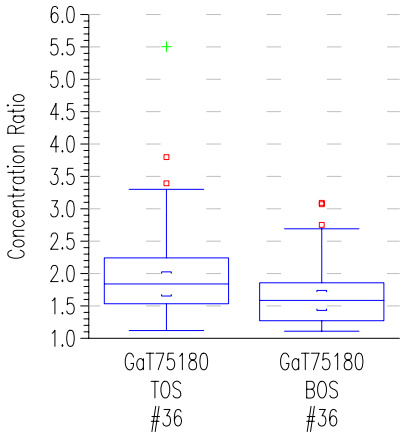
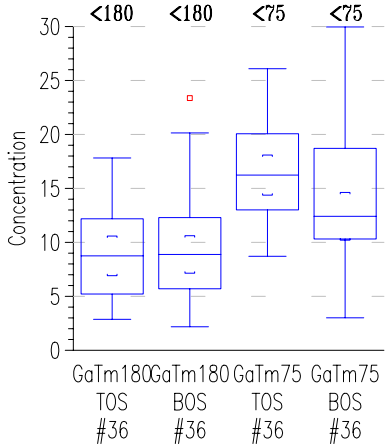
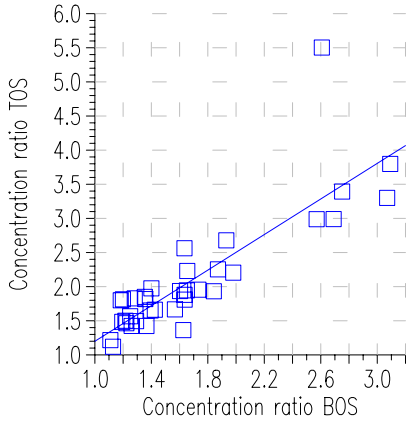
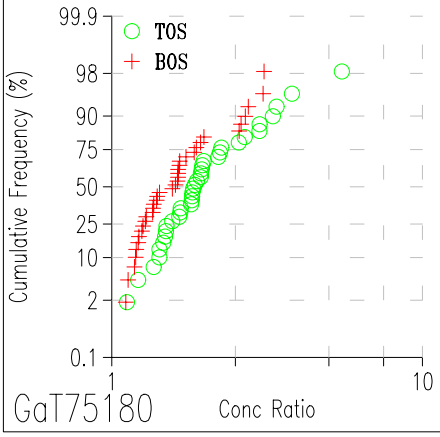
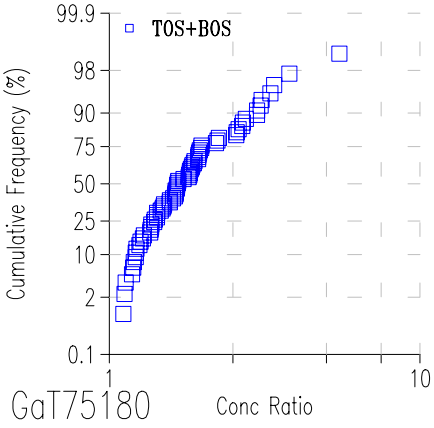
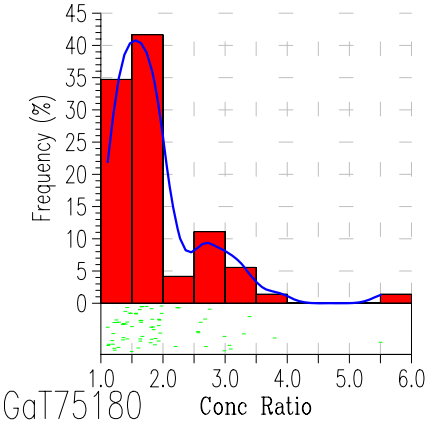
Top & Bottom Outlet Sediments (TOS & BOS)



GAWLER GEOCHEMICAL SURVEY

Top & Bottom Outlet Sediments (TOS & BOS)