DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2019/12

Magnetic Susceptibility study of Isortoq drill core

For Resource 500 FeVTi Ltd., 1 Marine Terrace, Dun Laoghaire Co. Dublin, Ireland

Diogo Rosa, Høgni Vesturklett & Nima H. Azad

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GEUS

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Confidential report

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Contents

Background 3

Study objectives 4

Methods 5

Results 6

Implications and recommendations 7

References 8

Background

In January 2019, core from the 2012 drill program carried out by West Melville Metals Inc. at the Isortoq Fe-Ti-V property, in South Greenland, arrived at the GEUS' storage facility in Rødovre, Copenhagen, Denmark. This facility constitutes an accessible and convenient location to study the core, before it is shipped back to the Kangerlussuaq core depot, in Greenland. Within this context, GEUS has agreed to reorganize and relabel the 2 671 m of core, from 11 drill holes, and systematically measure the magnetic susceptibility (MS) along it.

As such, this report fulfils the deliverables listed on points 3.2 and 3.3 of the contract signed between Resource 500 FeVTi Ltd and GEUS, on February 4th, 2019, namely:

-provides files and plots of measured MS values against drill depth (average of one MS recording/meter) for the eleven holes;

-describes the study objectives and the MS meter used;

-discusses main implications and recommendations.

Study objectives

Magnetic susceptibility of a rock is essentially controlled by the type and amount of minerals it contains. Often this control is exerted by the presence of relatively small quantities of ferromagnetic minerals (namely magnetite and/or pyrrhotite), characterized by the existence of spontaneously magnetized sublattices even in the absence of external magnetic field. Figure 1 shows how different mineral concentrations contribute to rock magnetic susceptibility, namely how even small concentrations of magnetite can increase susceptibility more than larger concentrations of other minerals (for ex. 100 % of mafic silicates contribute less than 1% of magnetite). This suggests measurement of MS should be a powerful tool to establish magnetite contents of the Isortoq troctolite, believed to be the carrier mineral for potentially economic concentrations of titanium and vanadium (Caira, 2012; Ferguson, 2013; Turner & Nichols, 2013).

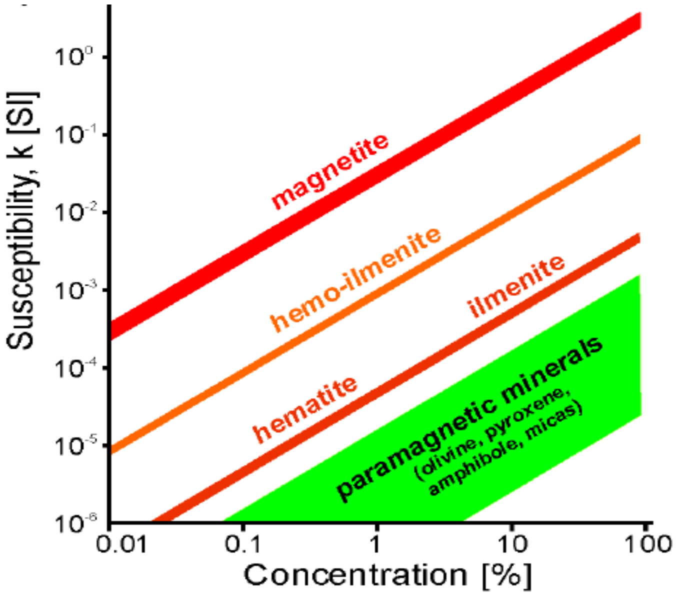

Figure 1. *Magnetic susceptibility contribution of minerals according to their concentrations. From Hrouda et al (2009).*

Therefore, the aim of the carried out work was to test a correlation between newly measured MS values and the bulk chemistry obtained by West Melville Metals (reported by Ferguson, 2013), in drill core from the eleven holes drilled by this company in 2012 at Isortoq. Confirmation of such a correlation would make MS measurements a strong, quick and low-cost tool for field mapping for titanium and vanadium in other parts of the Isortoq dyke system. It will also help to constrain which portions of the dyke could be subject to studies of grain size/morphology and mineralogy using scanning electron microscope instrumentation, as well as providing important petrophysics parameters for inversion of magnetic geophysical surveys of the dyke systems.

Methods

Subsequent to reorganization and relabelling of the core boxes (Figure 2), overview photos of the core were acquired, and its MS was systematically measured with a spacing of one meter, along the core of all the 11 drill holes, both on troctolite and granite intervals.

Magnetic susceptibility measurements were made using a KT-10 magnetic susceptibility meter, jointly designed by Terraplus Inc (Canada) and Georadis S.R.O. (Czech Republic). This handheld instrument uses an oscillator with an inductive coil to quickly measure the magnetic susceptibility.

Figure 2. *Photos illustrating the staked and relabelled core, subsequent to reorganization.*

Results

Overview photos, essentially to document the fracture intensity and veining within the core, are included as an attached zip folder (in CD).

All the MS measurements are reported in the attached excel file, with MS values intercalated with the whole rock geochemical results from WestMelville Metals (in CD).

Figures 3 through 13, illustrate logs in which MS readings are plotted against drill depth, for each of the studied 11 drill cores. Lithological composition, as determined by West-Melville Metals, is also displayed along the depth axis, with troctolite intervals shown in green and granite or syenite intervals shown in pink. For comparison, the available bulk geochemistry data for Fe_2O_3, TiO_2 and V_2O_5 (for 2 m intervals, from Ferguson, 2013) are shown for each of the figures.

Since MS readings were collected with 1 m intervals, while geochemistry results refer to, normally, ≥2 m intervals, two or more MS readings were averaged out in order to test one-on-one relationships. This allowed to plot, for each of the 11 drill holes, scatter diagrams relating the concentrations of each of the three oxides of interest to the averaged out MS readings within a given interval (figures 14-24). Summarizing these results, correlation matrices, showing correlation coefficients relating oxide concentrations and MS readings, are also included in the figures.

Geochemical analysis of the 72,0-74,0 m interval of DH07, with 81% Fe_2O_3, 1.52 % TiO_2 and 0.022% V_2O_5 is rather suspicious and was considered to reflect an analytical error. Therefore, these values are highlighted on the logs of Figure 9 (with Fe_2O_3 off the scale), and this interval was not considered for the scatter diagrams and correlation matrix of Figure 20.

DH02 at a depth 38.9 m provided a relatively low MS reading, despite of the high concentrations of Fe_2O_3, TiO_2 and V_2O_5 in the encompassing 0.91 m of core. As can be seen in the core photographs (see CD), the 38.9 m mark corresponds to what appears to be a paler vein, presumably lacking significant magnetite. The metals of interest are probably hosted in other, non-magnetic, mineral phases, or in magnetite away from where the MS reading was made. Because of this single reading, the correlation matrix of DH02 (Figure 15) yields somewhat weaker correlation coefficients between MS and oxide concentrations, when compared with those obtained in core from other drill holes.

Implications and recommendations

The logs (figures 3-13) clearly show that MS readings obtained in troctolite intervals are generally one order of magnitude higher than in granite/syenite intervals. In turn, within troctolite intervals, higher MS readings, reflecting more abundant magnetite, correspond to intervals with higher Fe_2O_3, TiO_2 and V_2O_5 concentrations. Higher Fe_2O_3, TiO_2 and V_2O_5 concentrations and MS readings are found in the internal part of the dyke, suggesting that post-magmatic hydrothermal alteration or supergene processes might have partially destroyed magnetite grains and promoted some leaching of the metals 10-20 m along the dyke margins. Alternatively, the reported variation could be accounted for by multiple magma injections. Which of these processes operated can only be more firmly established through petrographic means. However, the fact that on vertical holes DH01 and DH10, the Fe_2O_3, TiO_2 and V_2O_5 concentrations and MS readings are not lower in their shallower part, suggests that hydrothermal alteration along margins, rather than supergene weathering close to the surface, could be the cause for the lower concentrations and MS readings seen within troctolite closer to granite/syenite contacts in other holes.

As seen on the scatter diagrams, MS values display positive correlation with Fe_2O_3, TiO_2 and V_2O_5 concentrations in each of the studied drill cores. For most of the drill cores, inflexion points at MS values of approximately 50 are evident. These mark different regression slopes for granite/syenite intervals (MS < 50 x 10^{-3} SI) and troctolite intervals (MS > 50 x 10^{-3} SI).

Correlation matrices show strong to very strong correlations coefficients between MS and oxide concentration. Since these correlation matrices were calculated for complete cores, meaning that in most cases these include both trocolite and granite/syenite intervals with different regression slopes, correlation coefficients between oxide concentrations and MS readings should be even better if one would consider each rock type separately. The oxide displaying the largest correlation coefficient with MS is consistently V_2O_5, suggesting that magnetite accounts for an even larger proportion of the vanadium than of the iron or titanium. The latter elements, albeit still overwhelmingly hosted by magnetite, are also present in other, non-magnetic, mineral phases (such as ferro-magnesian silicates olivine and pyroxene, and the oxides hematite and ilmenite), than the former element.

In summary, MS readings constitute a suitable tool for field mapping of the titanium and vanadium distribution in the Isortoq dyke system. Magnetic susceptibility values should also be used to identify which portions of the dyke could be subject to studies of grain size/morphology and mineralogy using scanning electron microscope instrumentation. Finally, the present study provides important petrophysics parameters to be used for inversion of magnetic geophysical surveys of the dyke systems.

References

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Hrouda, F., Chlupacova, M., and Chadima, M., 2009, The use of magnetic susceptibility of rocks in geological exploration (case histories study), a Terraplus report available online at: www.terraplus.ca/products/pdf/case-study-susceptibility.pdf

Turner, A.J., and Nicholls, S.J., 2013, NI33-101 Technical Report on an initial resource estimate for the Isortoq Fe-Ti-V project, Qaqortoq district, South Greenland. Prepared by APEX Geoscience Ltd. on behalf of West Melville Metals Inc.

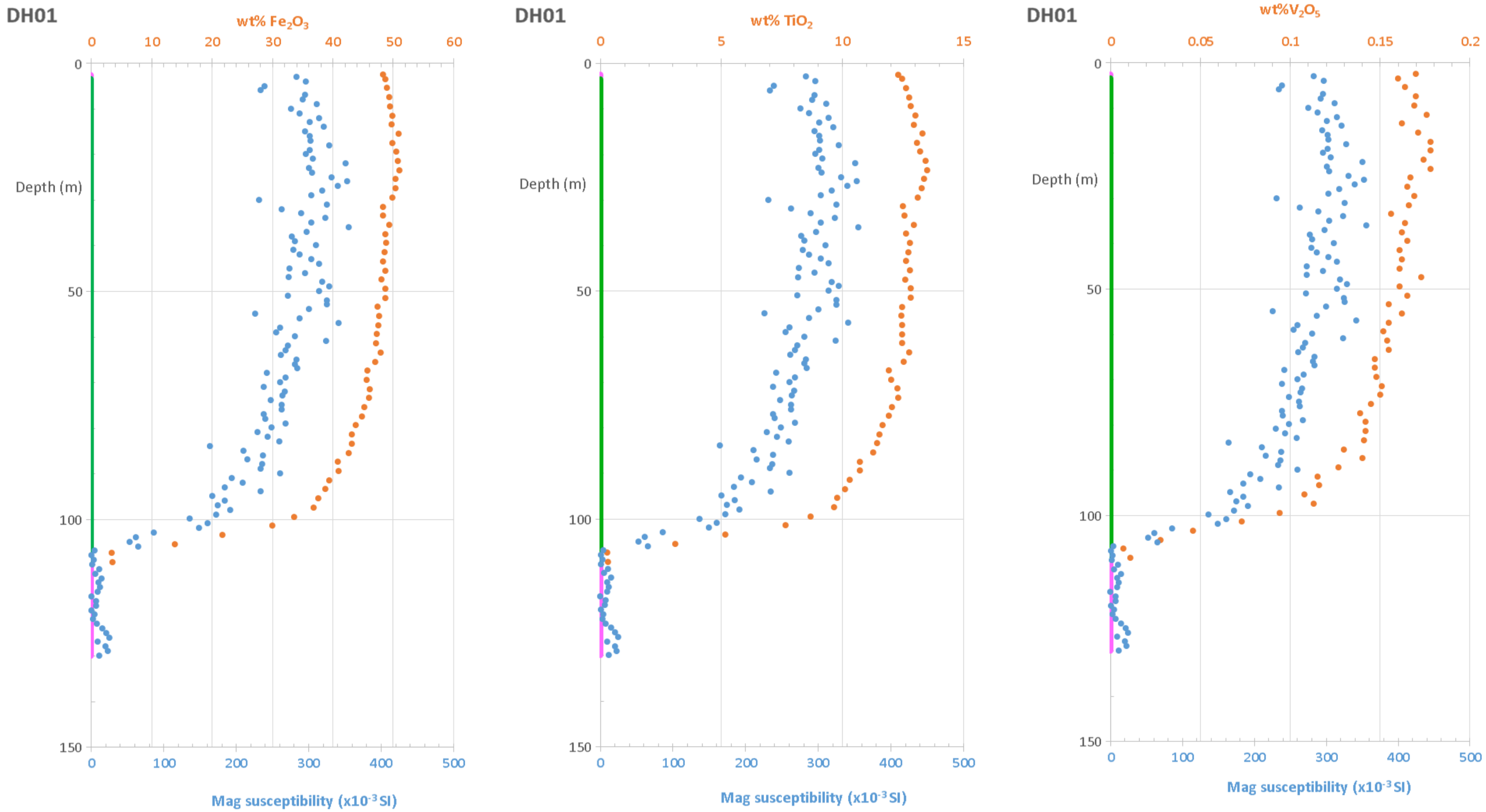


Figure 3. *MS / geochemistry logs of DH01.*

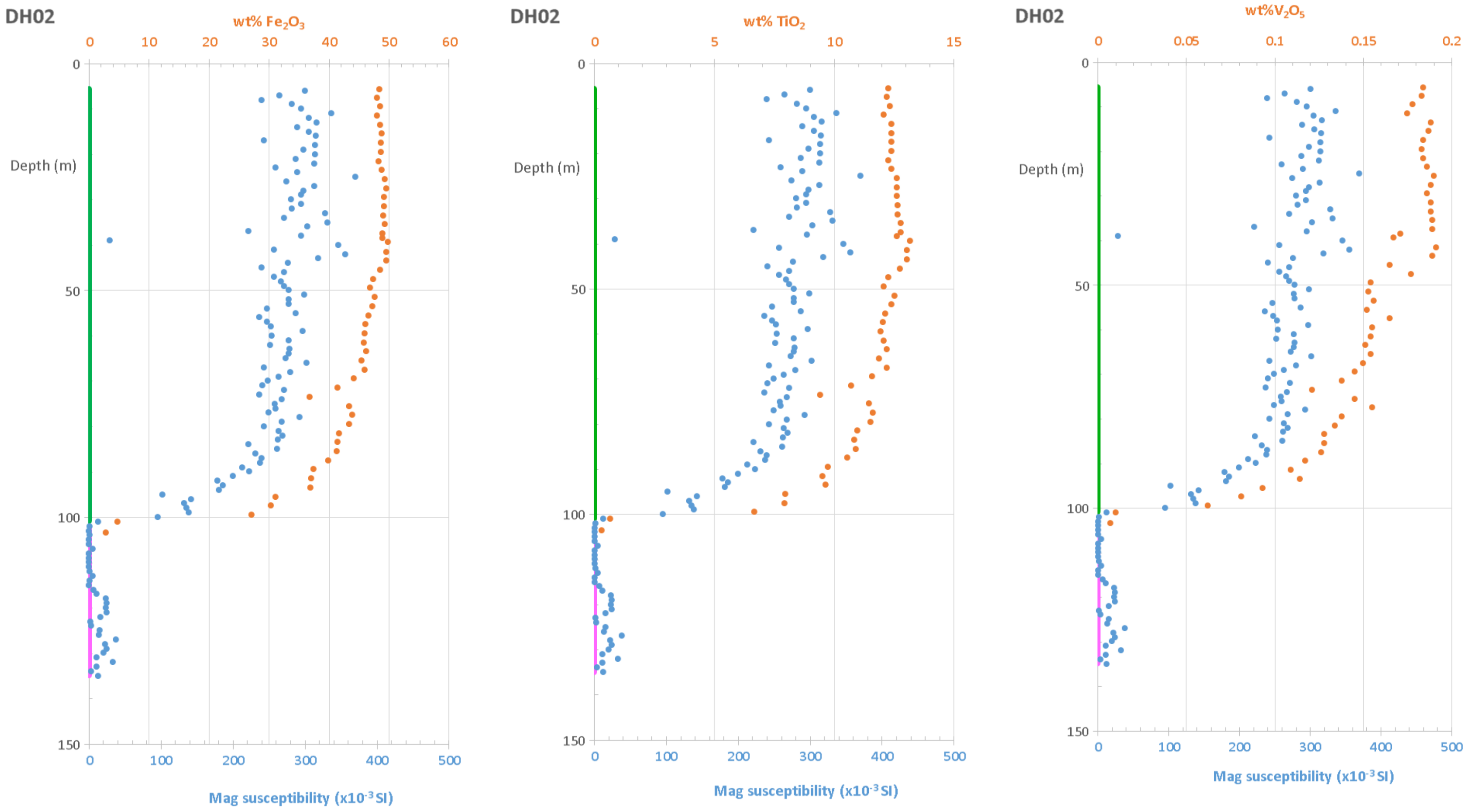


Figure 4. *MS / geochemistry logs of DH02.*

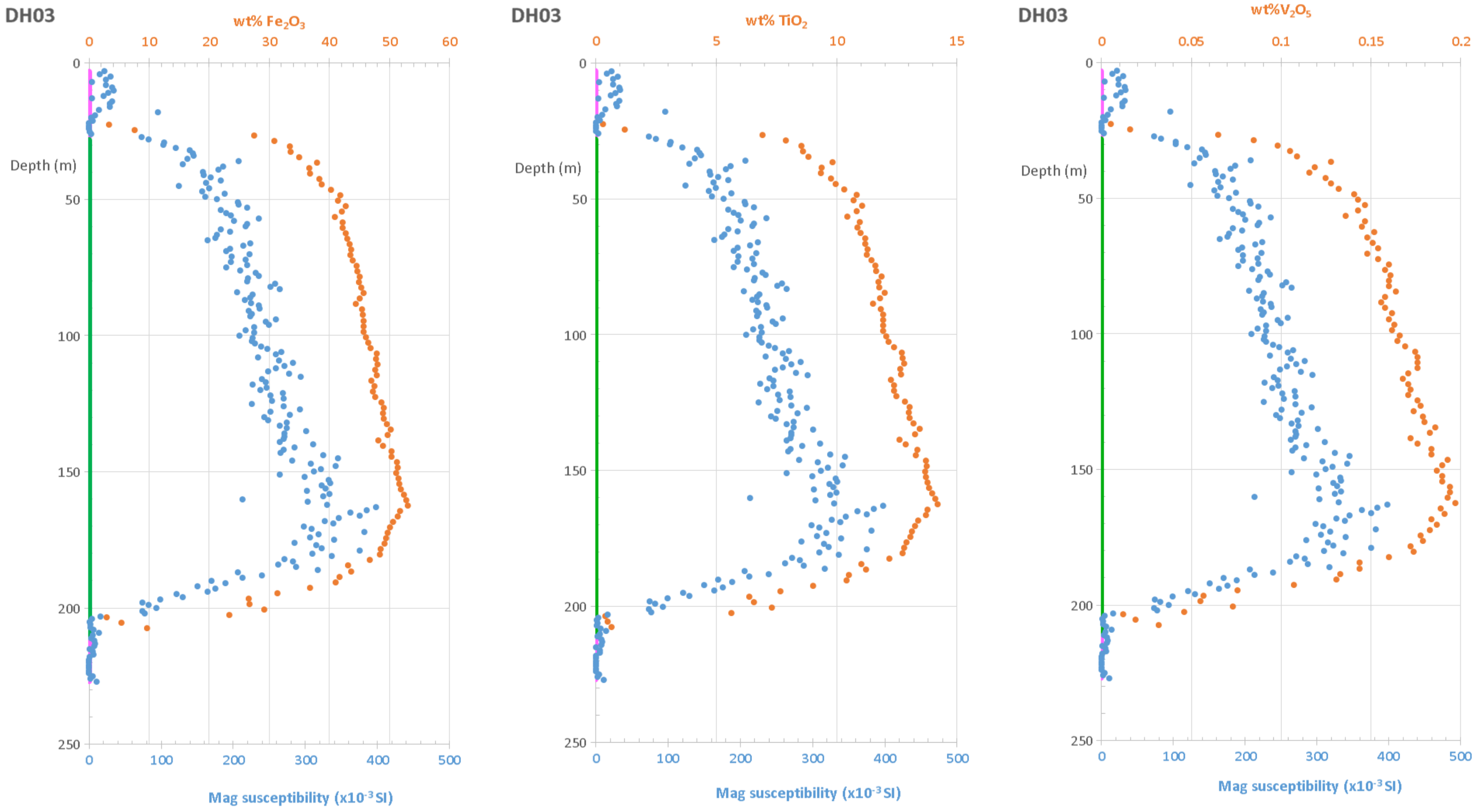


Figure 5. *MS / geochemistry logs of DH03.*

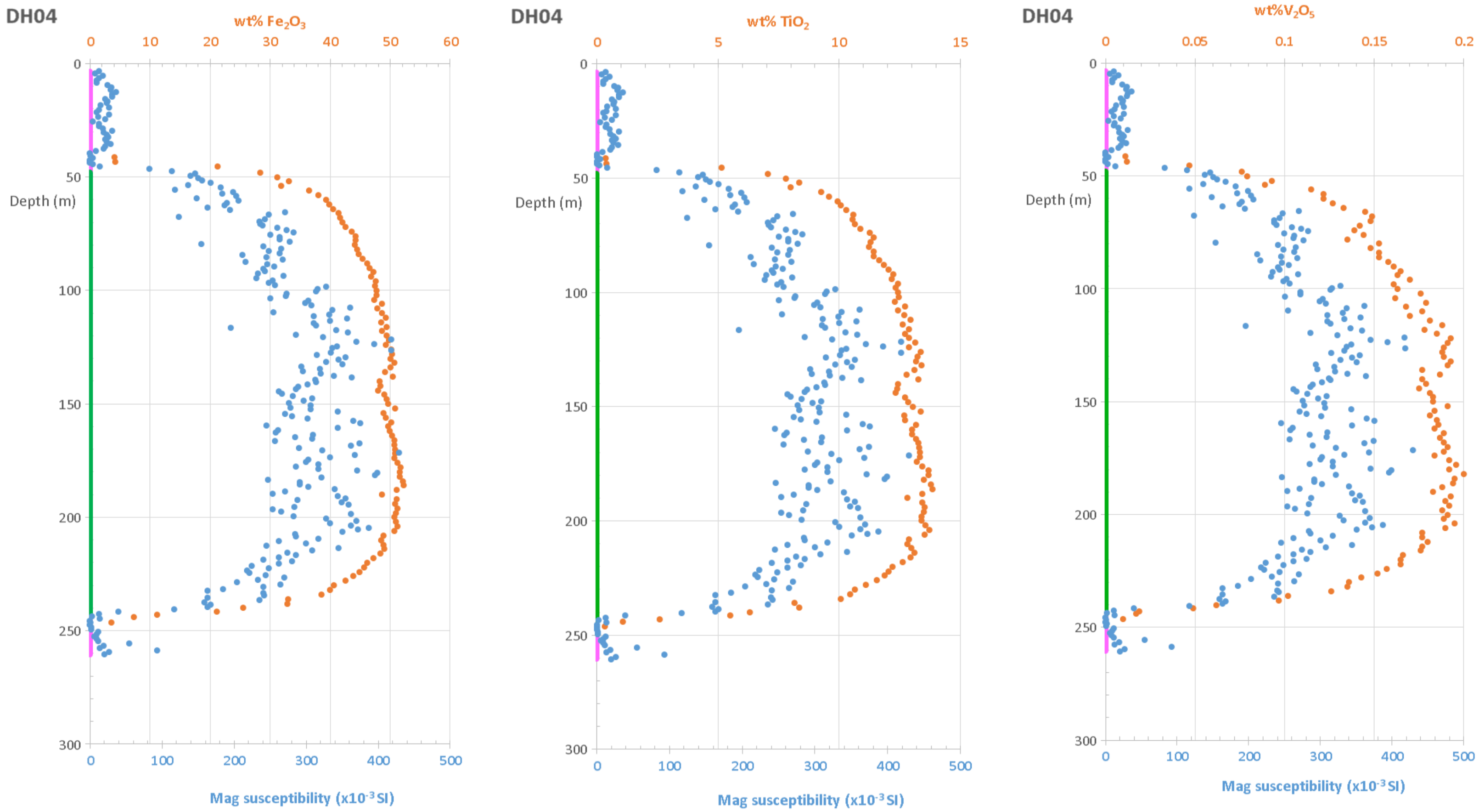


Figure 6. *MS / geochemistry logs of DH04.*

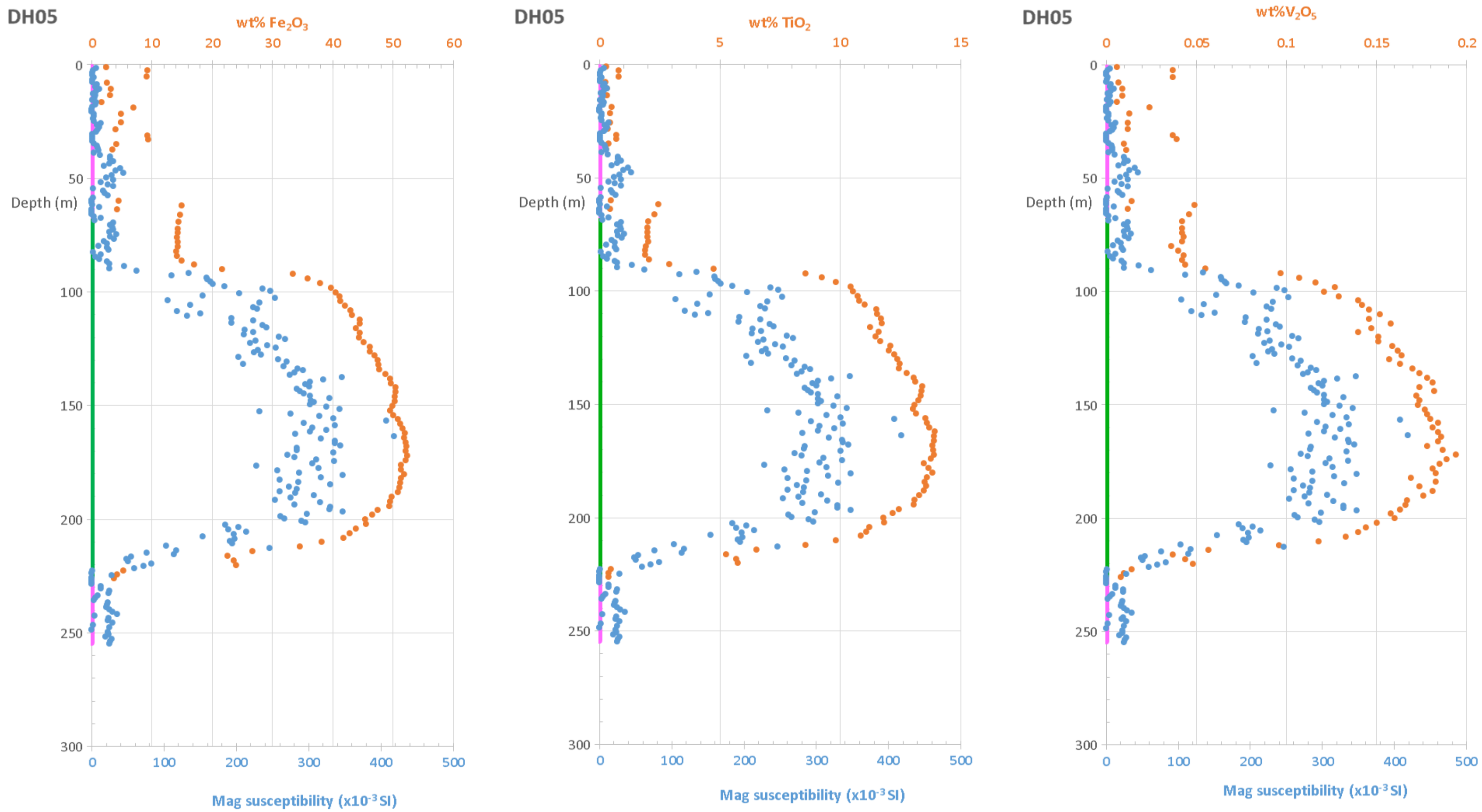


Figure 7. *MS / geochemistry logs of DH05.*

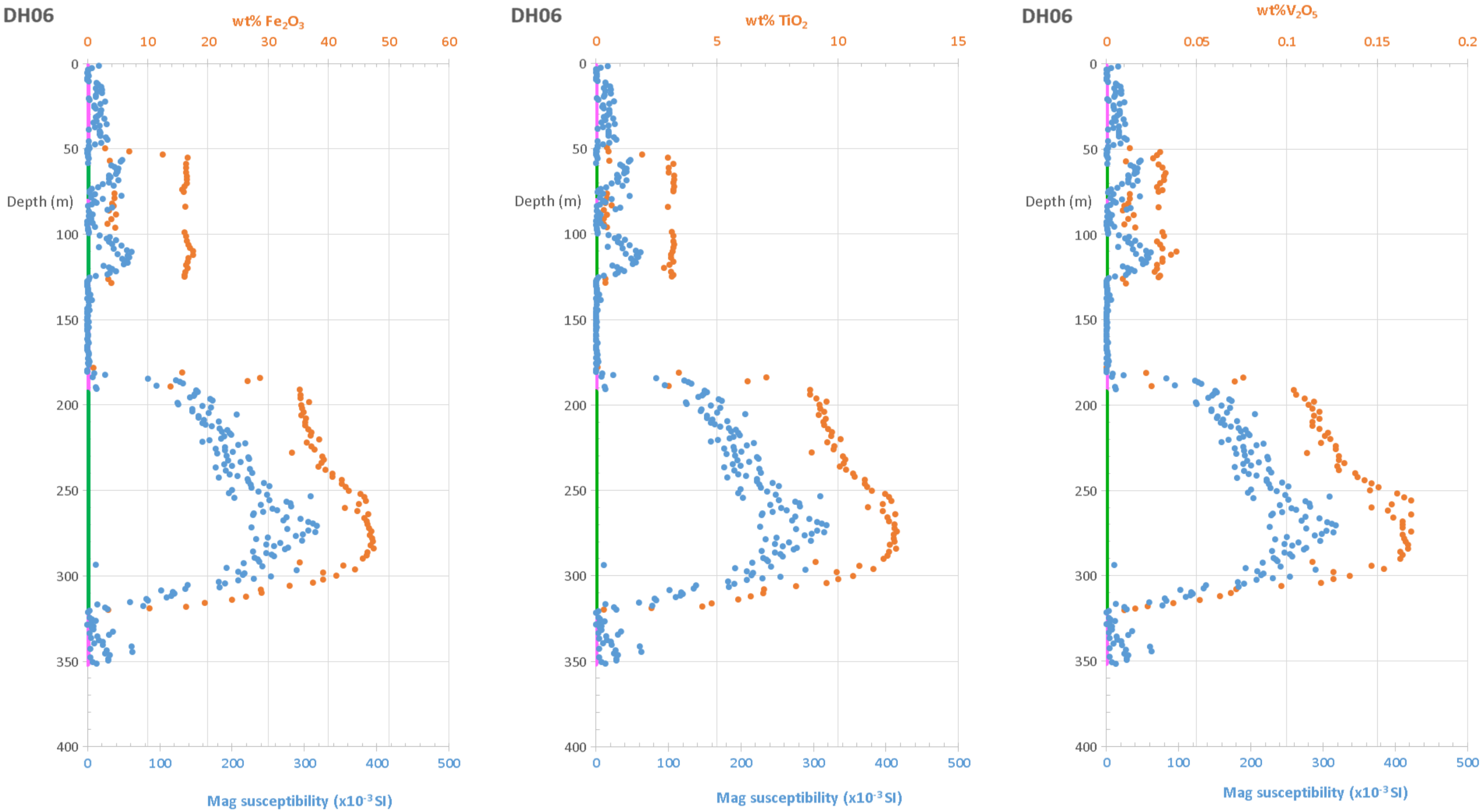


Figure 8. *MS / geochemistry logs of DH06.*

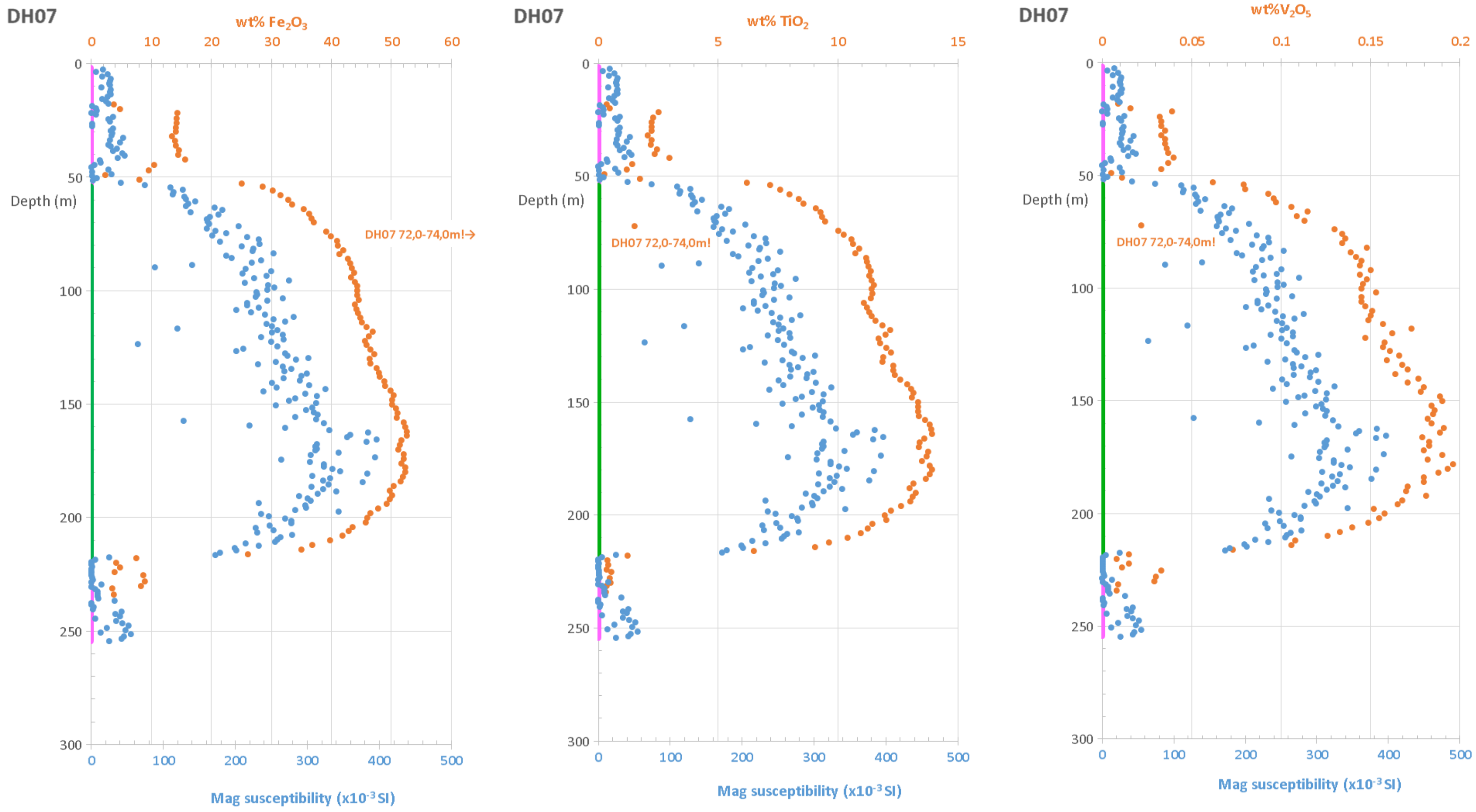


Figure 9. *MS / geochemistry logs of DH07.*

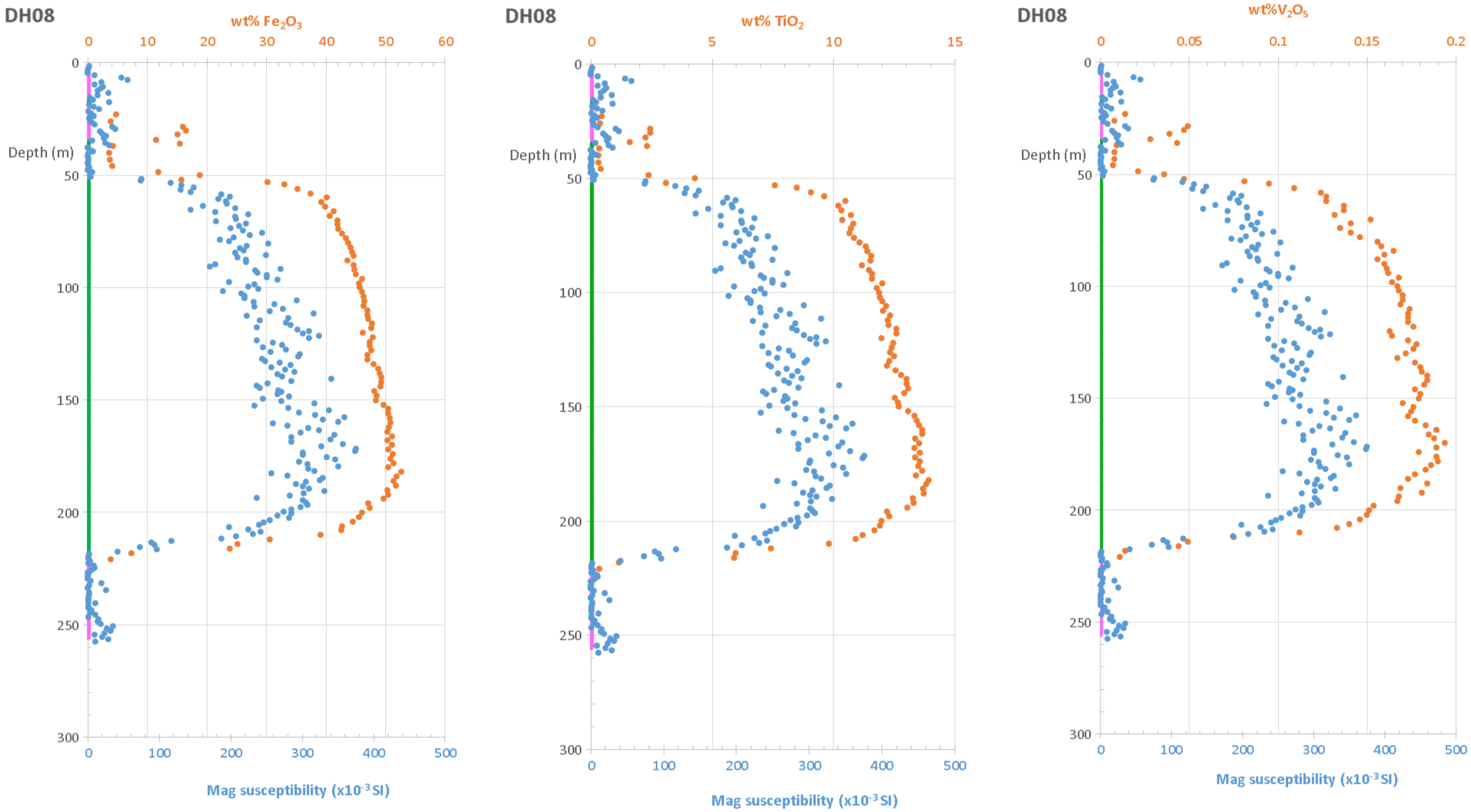


Figure 10. *MS / geochemistry logs of DH08.*

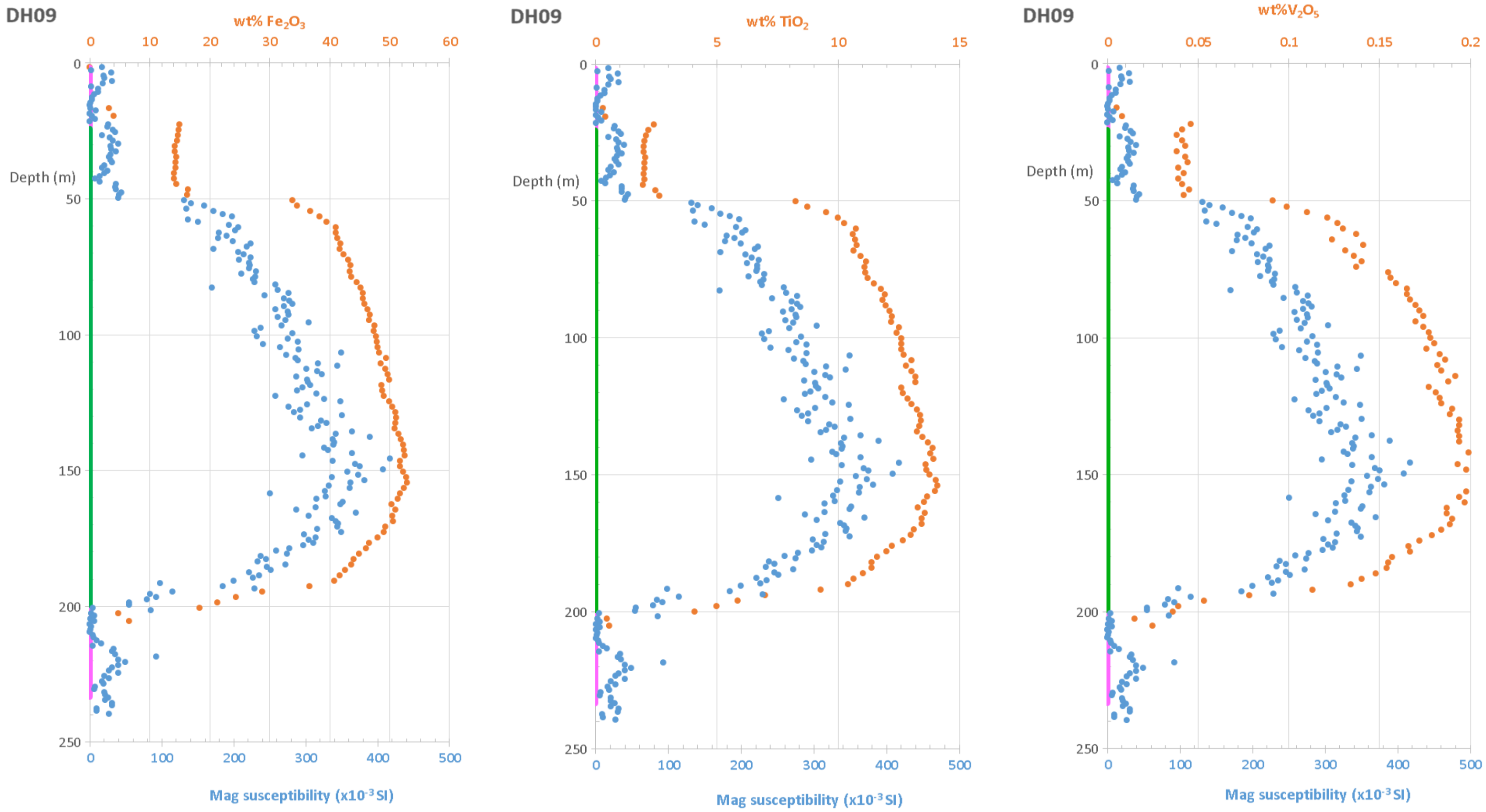


Figure 11. *MS / geochemistry logs of DH09.*

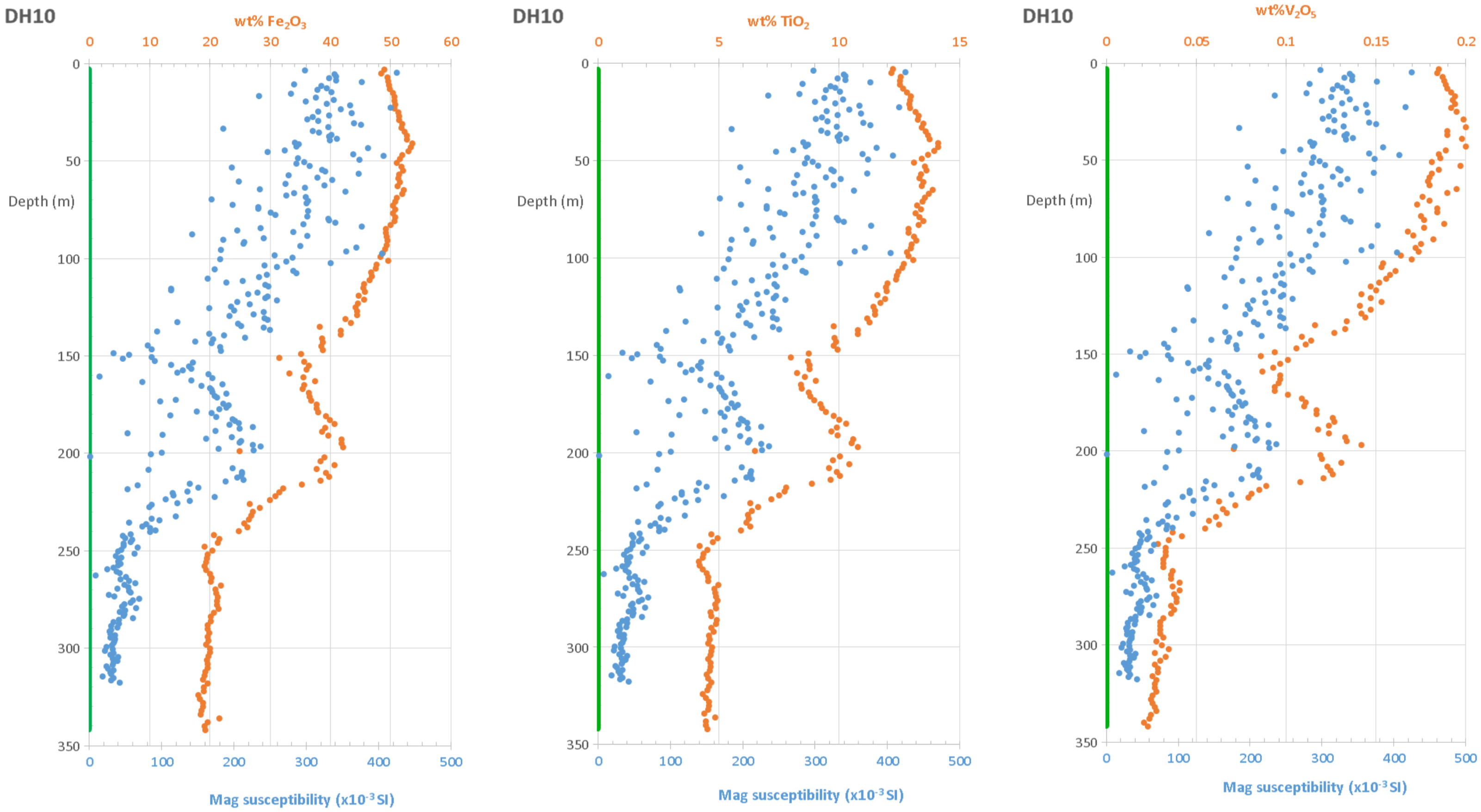


Figure 12. *MS / geochemistry logs of DH10.*

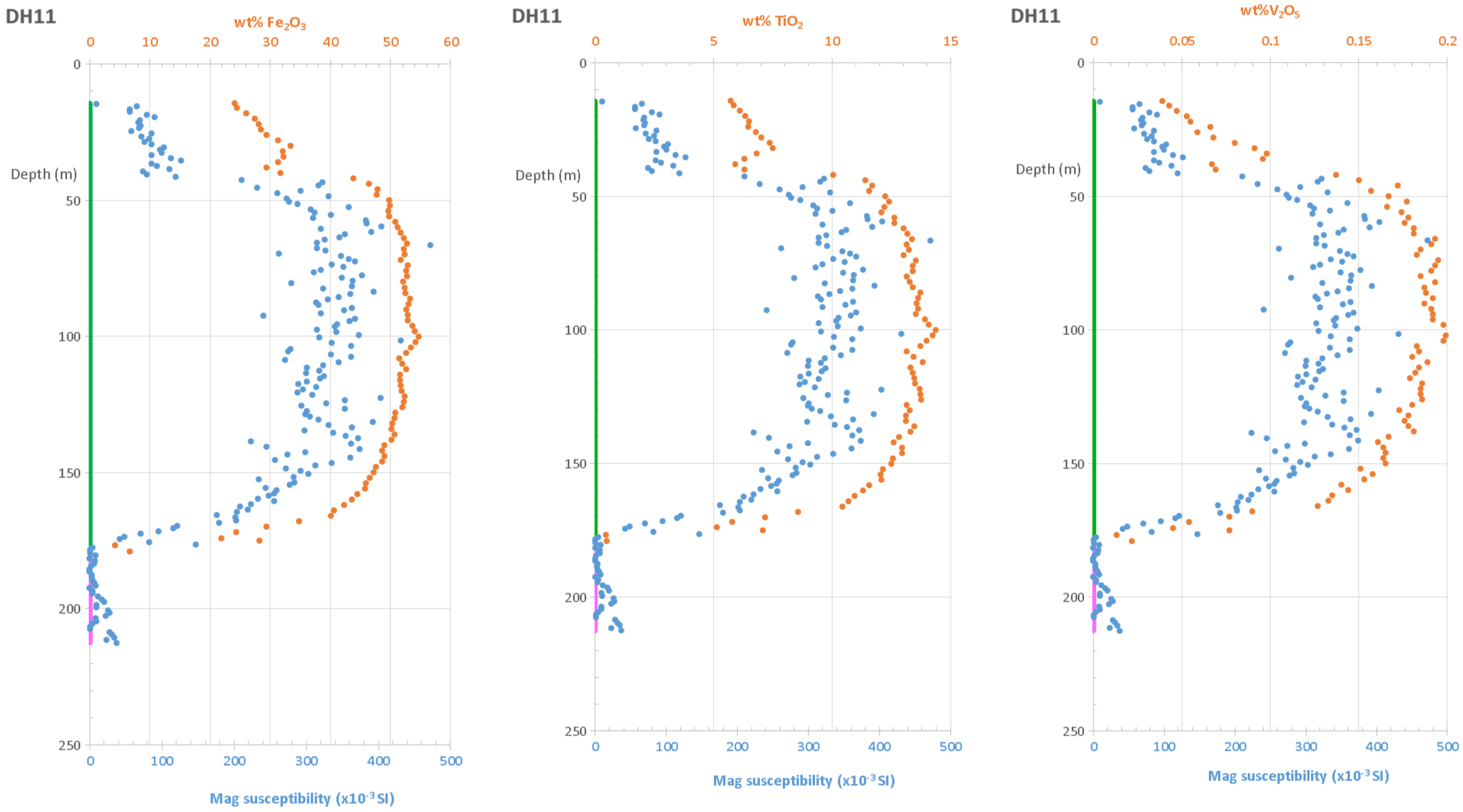
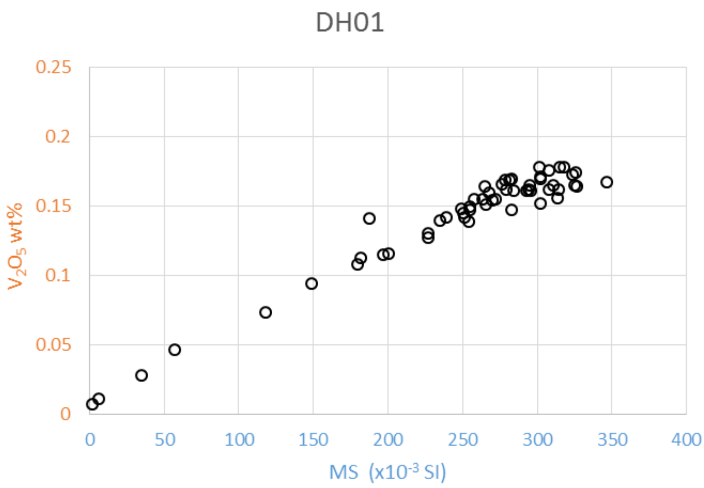
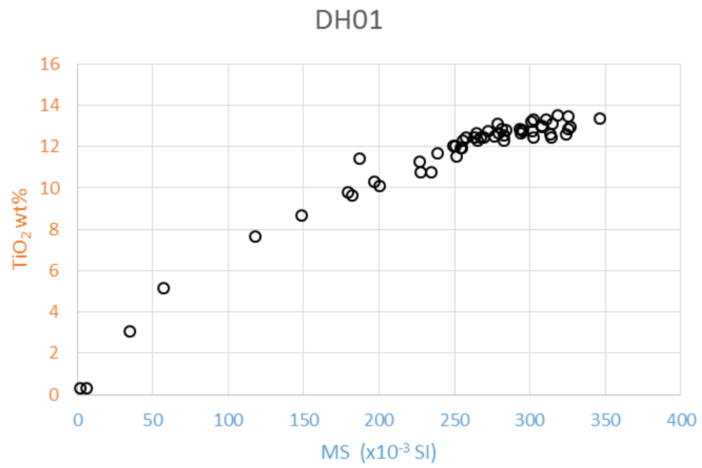
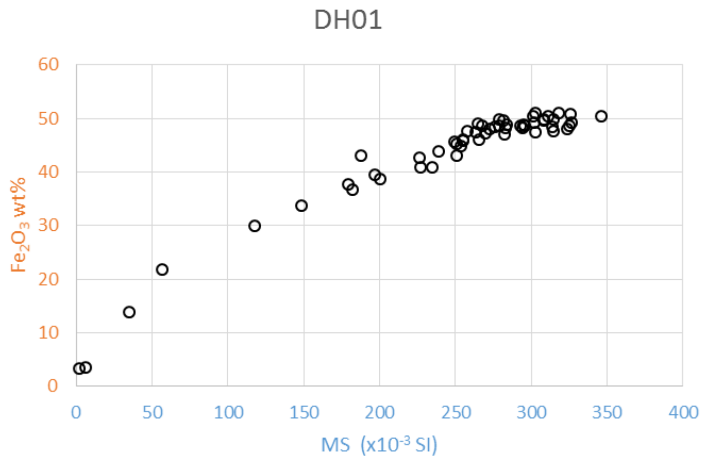


Figure 13. *MS / geochemistry logs of DH11.*

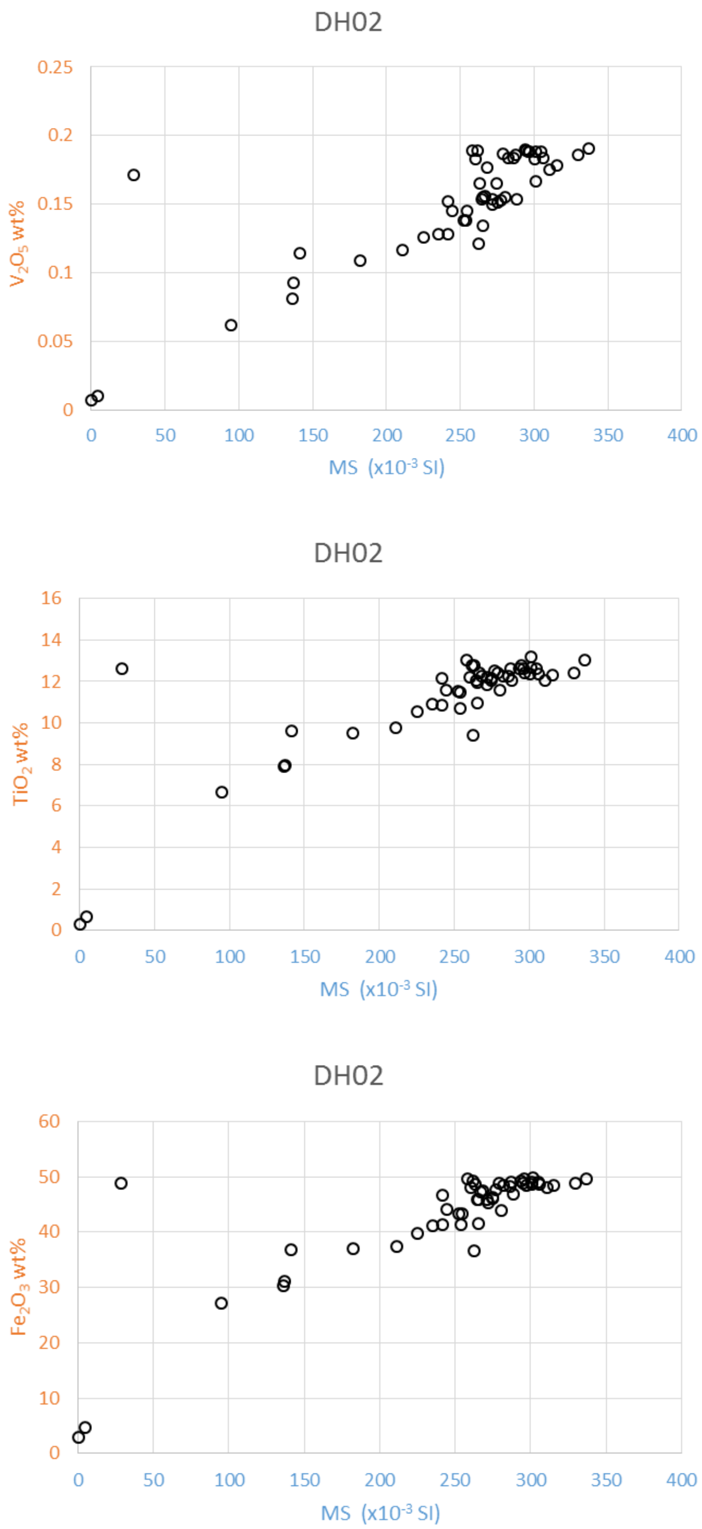






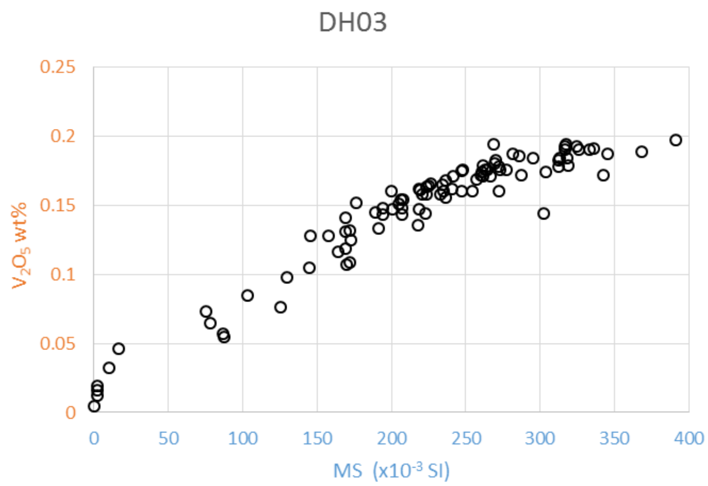
	Ave MS value	*Fe2O3(T)_%_FUS-XRF*	*TiO2_%_FUS-XRF*	*V2O5_%_FUS-XRF*
Ave MS value	1.0000			
Fe2O3(T)_%_FUS-XRF	0.9586	1.0000		
TiO2_%_FUS-XRF	0.9569	0.9988	1.0000	
V2O5_%_FUS-XRF	0.9730	0.9831	0.9796	1.0000

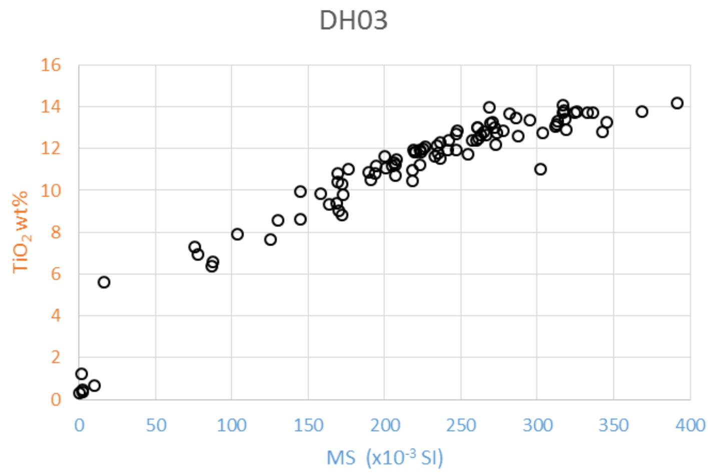
Figure 14. *Scatter diagrams and correlation matrix for DH01.*

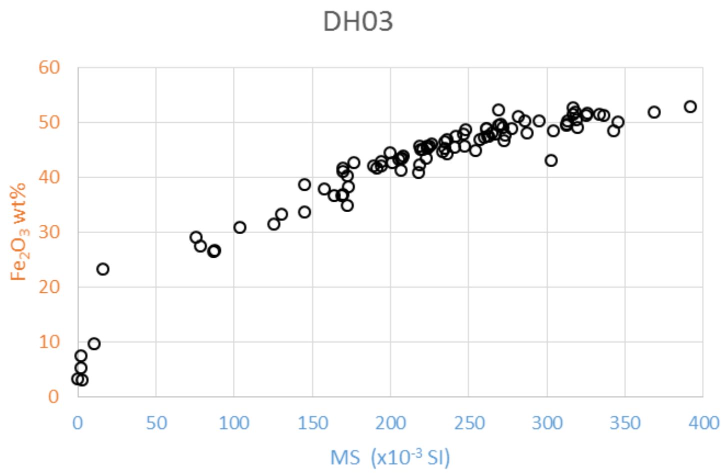


	Ave MS value	*Fe2O3(T)_%_FUS-XRF*	*TiO2_%_FUS-XRF*	*V2O5_%_FUS-XRF*
Ave MS value	1.0000			
Fe2O3(T)_%_FUS-XRF	0.8298	1.0000		
TiO2_%_FUS-XRF	0.8258	0.9971	1.0000	
V2O5_%_FUS-XRF	0.8291	0.9584	0.9420	1.0000

Figure 15. *Scatter diagrams and correlation matrix for DH02.*

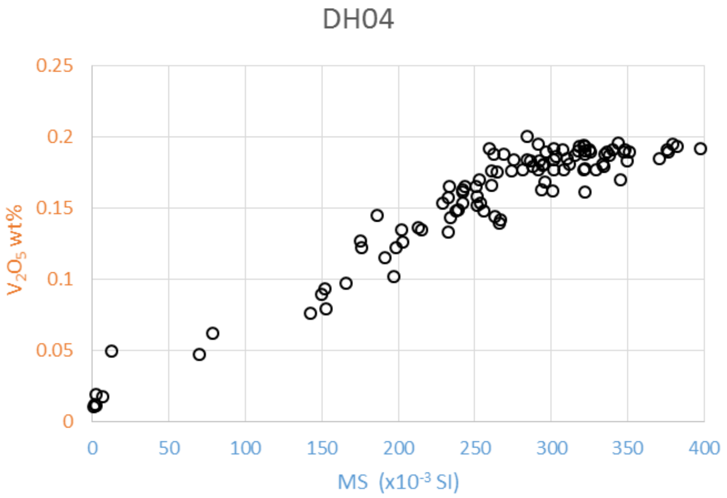


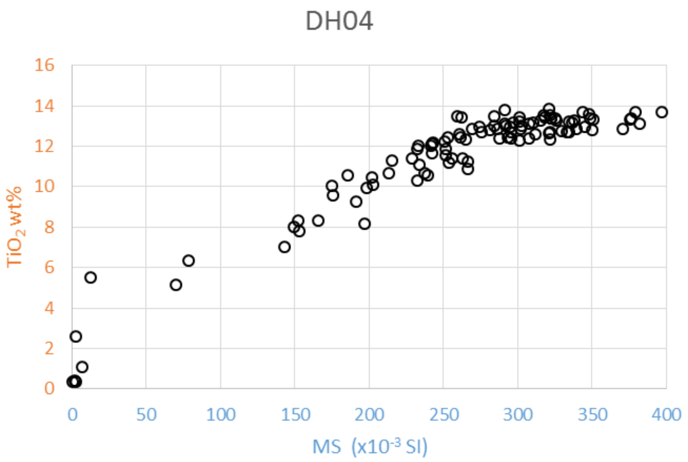


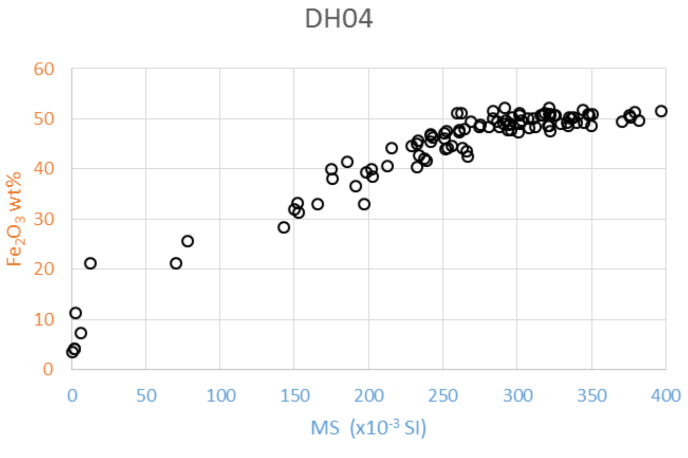


	Ave MS value	*Fe2O3(T)_%_FUS-XRF*	*TiO2_%_FUS-XRF*	*V2O5_%_FUS-XRF*
Ave MS value	1.0000			
Fe2O3(T)_%_FUS-XRF	0.9257	1.0000		
TiO2_%_FUS-XRF	0.9286	0.9985	1.0000	
V2O5_%_FUS-XRF	0.9475	0.9796	0.9810	1.0000

Figure 16. *Scatter diagrams and correlation matrix for DH03.*







	Ave MS value	*Fe2O3(T)_%_FUS-XRF*	*TiO2_%_FUS-XRF*	*V2O5_%_FUS-XRF*
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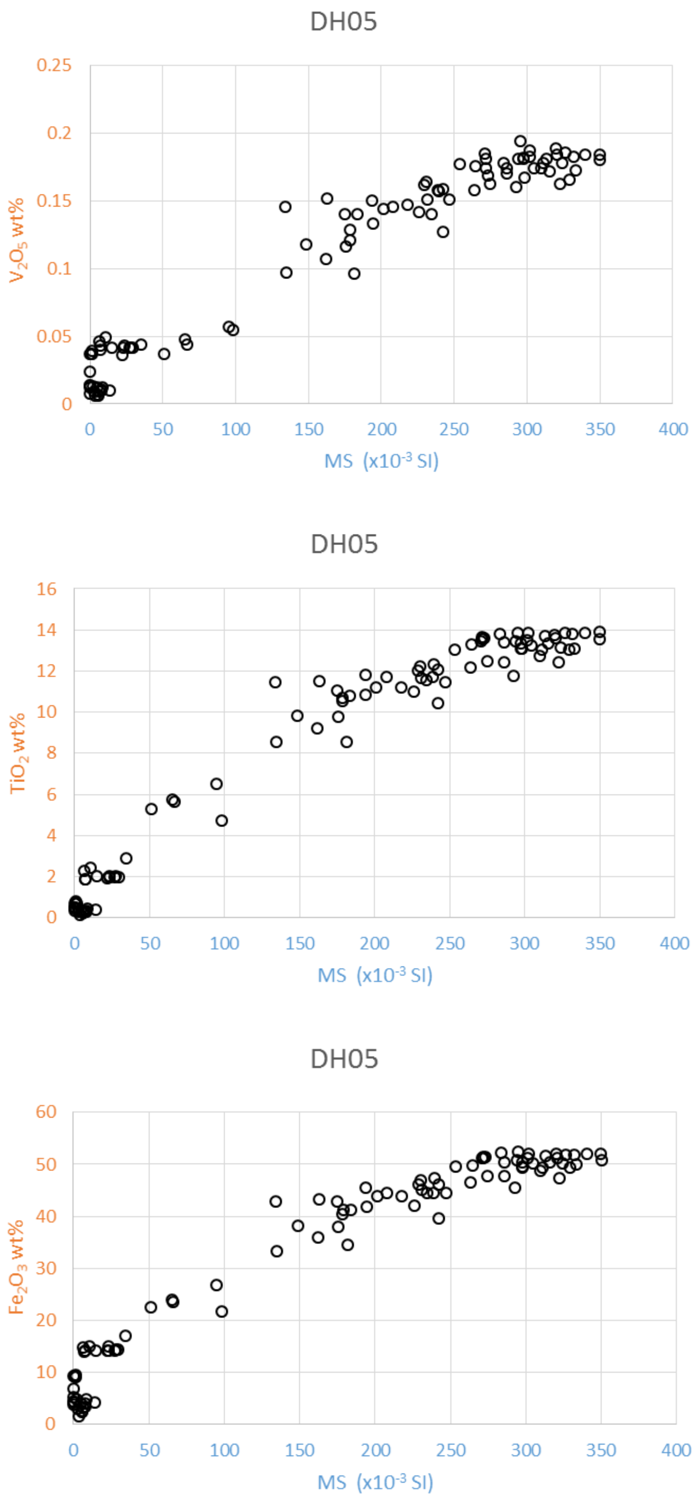
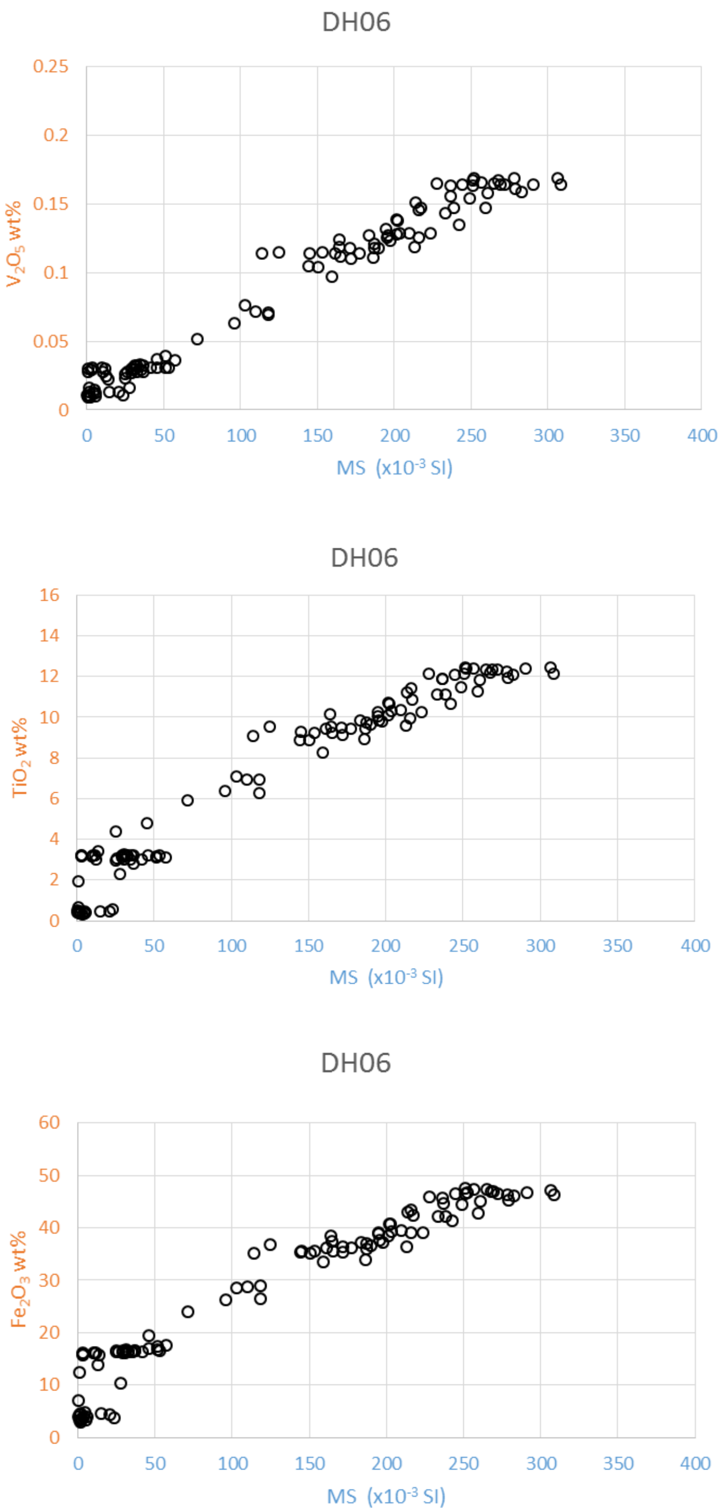
Fe2O3(T)_%_FUS-XRF	0.9331	1.0000		
TiO2_%_FUS-XRF	0.9344	0.9989	1.0000	
V2O5_%_FUS-XRF	0.9478	0.9812	0.9825	1.0000

Figure 17. *Scatter diagrams and correlation matrix for DH04.*



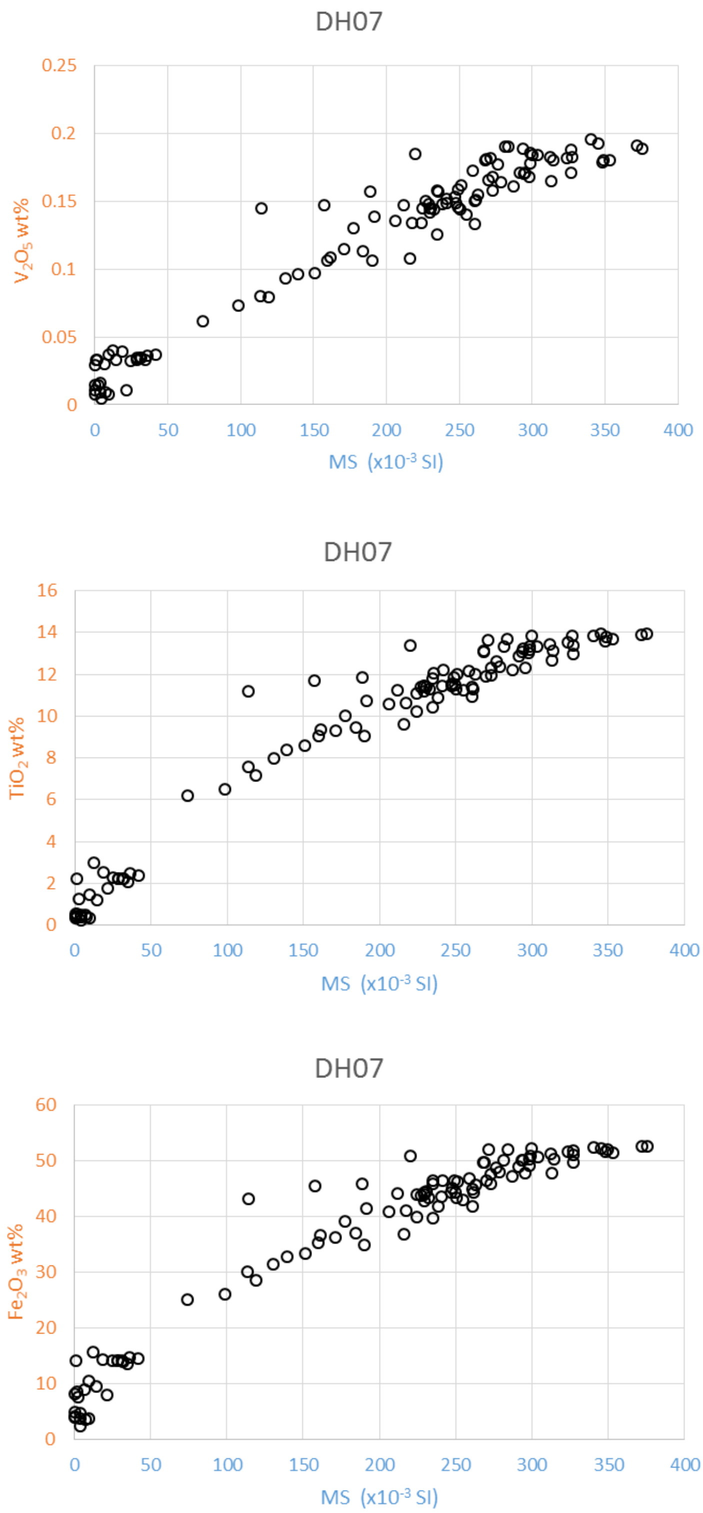
	Ave MS value	*Fe2O3(T)_%_FUS-XRF*	*TiO2_%_FUS-XRF*	*V2O5_%_FUS-XRF*
Ave MS value	1.0000			
Fe2O3(T)_%_FUS-XRF	0.9654	1.0000		
TiO2_%_FUS-XRF	0.9702	0.9971	1.0000	
V2O5_%_FUS-XRF	0.9727	0.9897	0.9875	1.0000

Figure 18. *Scatter diagrams and correlation matrix for DH05.*



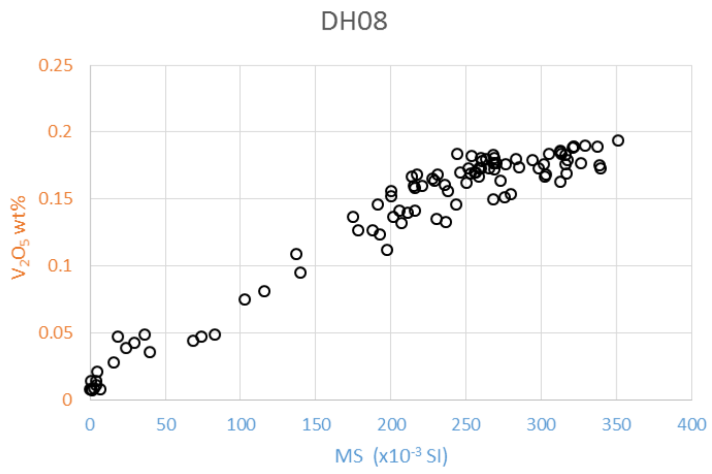
	Ave MS value	*Fe2O3(T)_%_FUS-XRF*	*TiO2_%_FUS-XRF*	*V2O5_%_FUS-XRF*
Ave MS value	1.0000			
Fe2O3(T)_%_FUS-XRF	0.9648	1.0000		
TiO2_%_FUS-XRF	0.9718	0.9968	1.0000	
V2O5_%_FUS-XRF	0.9844	0.9821	0.9879	1.0000

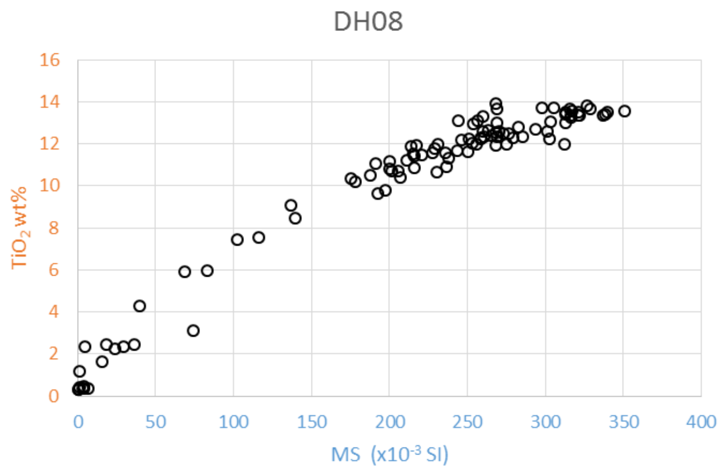
Figure 19. *Scatter diagrams and correlation matrix for DH06.*

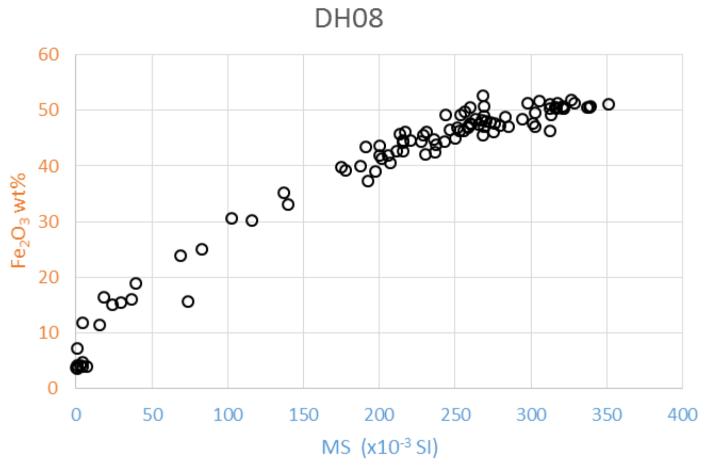


	Ave MS value	Fe2O3(T)_%_FUS-XRF	TiO2_%_FUS-XRF	V2O5_%_FUS-XRF
Ave MS value	1.0000			
Fe2O3(T)_%_FUS-XRF	0.9641	1.0000		
TiO2_%_FUS-XRF	0.9666	0.9981	1.0000	
V2O5_%_FUS-XRF	0.9698	0.9915	0.9894	1.0000

Figure 20. *Scatter diagrams and correlation matrix for DH07. Analysis of DH07 72-74m excluded.*

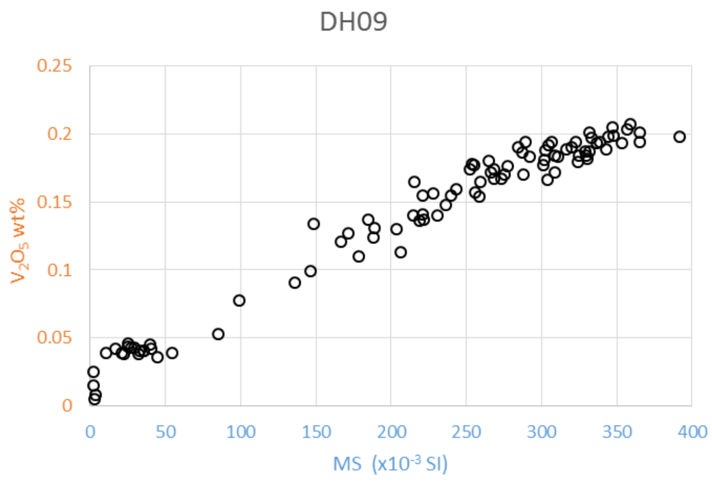


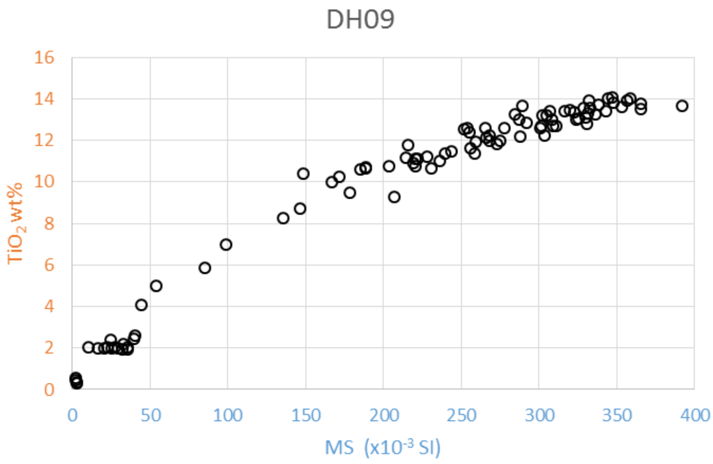


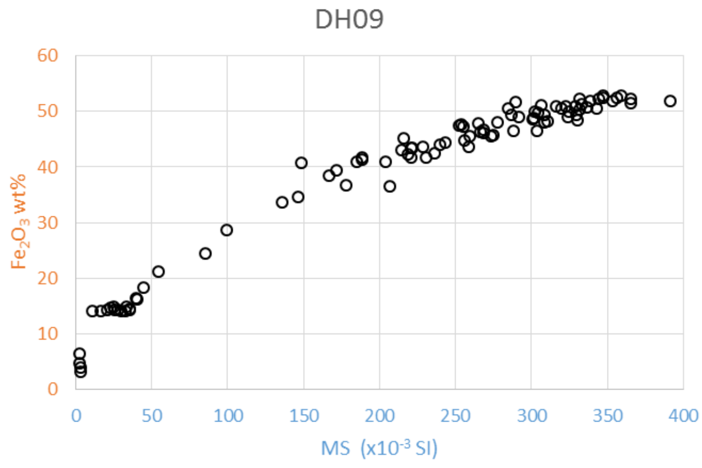


	Ave MS value	*Fe2O3(T)_%_FUS-XRF*	*TiO2_%_FUS-XRF*	*V2O5_%_FUS-XRF*
Ave MS value	1.0000			
Fe2O3(T)_%_FUS-XRF	0.9633	1.0000		
TiO2_%_FUS-XRF	0.9672	0.9981	1.0000	
V2O5_%_FUS-XRF	0.9663	0.9852	0.9844	1.0000

Figure 21. *Scatter diagrams and correlation matrix for DH08.*

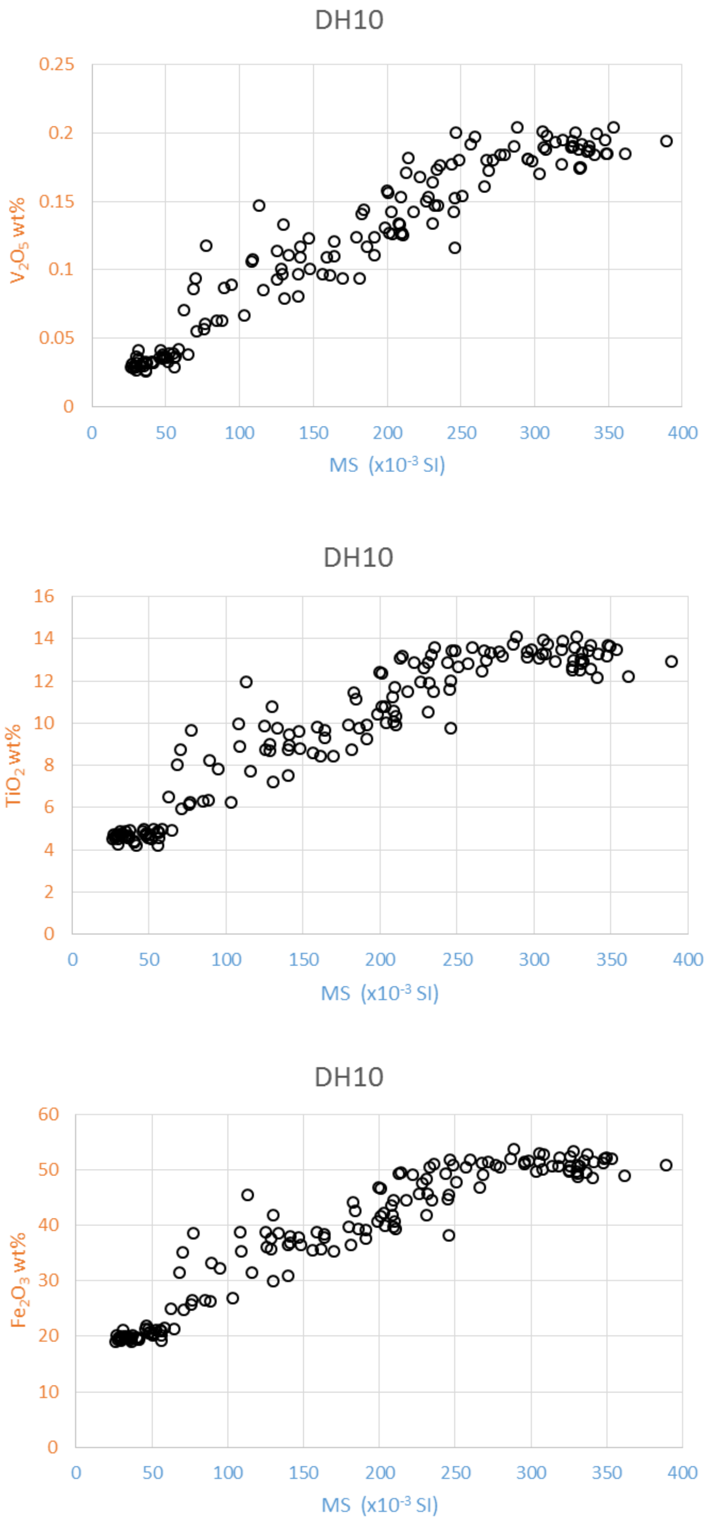






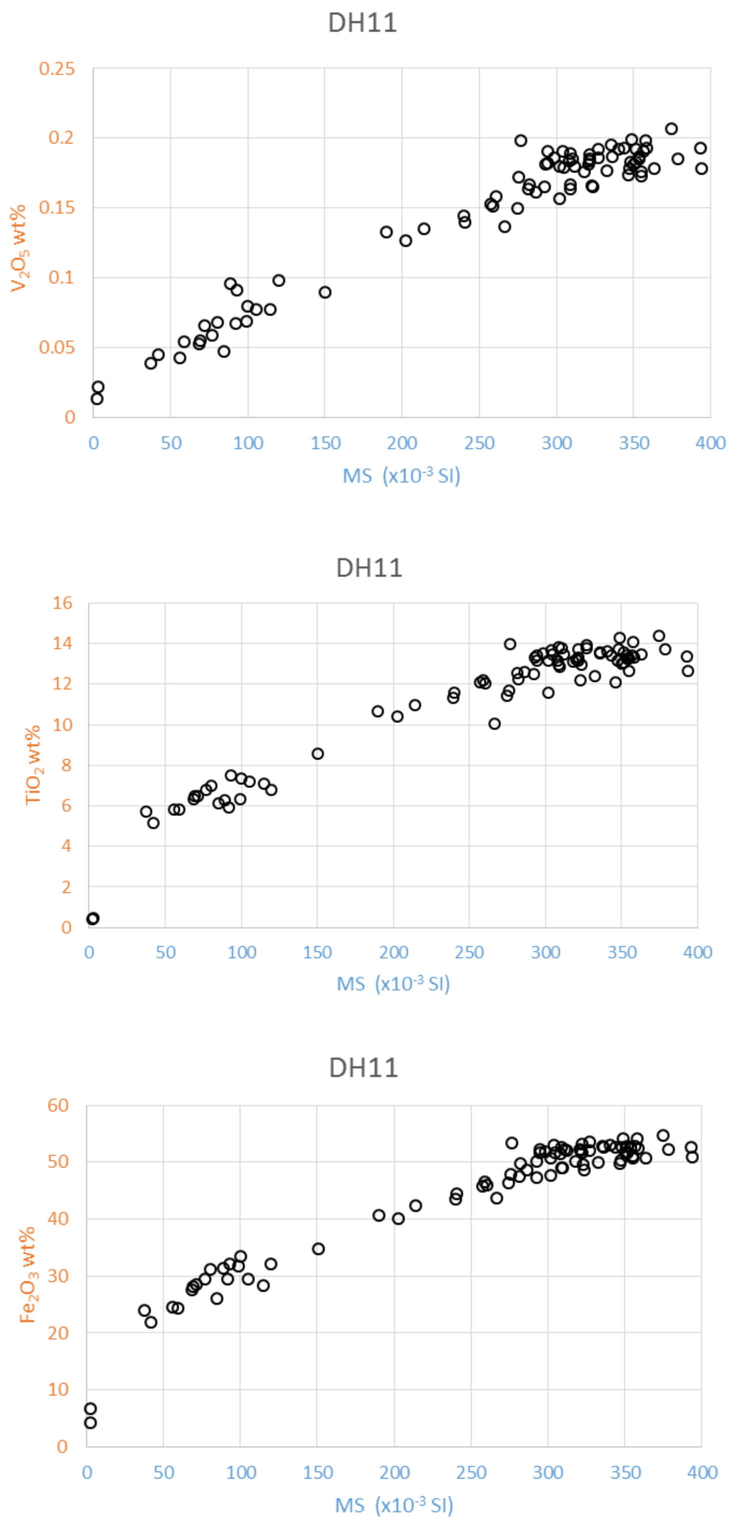
	Ave MS value	*Fe2O3(T)_%_FUS-XRF*	*TiO2_%_FUS-XRF*	*V2O5_%_FUS-XRF*
Ave MS value	1.0000			
Fe2O3(T)_%_FUS-XRF	0.9699	1.0000		
TiO2_%_FUS-XRF	0.9699	0.9979	1.0000	
V2O5_%_FUS-XRF	0.9833	0.9868	0.9838	1.0000

Figure 22. *Scatter diagrams and correlation matrix for DH09.*



	Ave MS value	*Fe2O3(T)_%_FUS-XRF*	*TiO2_%_FUS-XRF*	*V2O5_%_FUS-XRF*
Ave MS value	1.0000			
Fe2O3(T)_%_FUS-XRF	0.9433	1.0000		
TiO2_%_FUS-XRF	0.9365	0.9981	1.0000	
V2O5_%_FUS-XRF	0.9559	0.9935	0.9917	1.0000

Figure 23. *Scatter diagrams and correlation matrix for DH10.*



	Ave MS value	*Fe2O3(T)_%_FUS-XRF*	*TiO2_%_FUS-XRF*	*V2O5_%_FUS-XRF*
Ave MS value	1.0000			
Fe2O3(T)_%_FUS-XRF	0.9578	1.0000		
TiO2_%_FUS-XRF	0.9550	0.9918	1.0000	
V2O5_%_FUS-XRF	0.9719	0.9795	0.9775	1.0000

Figure 24. *Scatter diagrams and correlation matrix for DH11.*