Sorption Testing for Se, Tc, Np, U and Eu for IG_BH01, IG_BH03 and IG_BH05

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ABSTRACT

Title: **Sorption Testing for Se, Tc, Np, U and Eu for IG_BH01, IG_BH03 and IG_BH05**
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Abstract

McMaster University was contracted to measure sorption properties of Se, Tc, Np, U and Eu on 5 rock core samples (IG_BH01_SO001, IG_BH01_SO014, IG_BH03_SO002 (all are biotite granodiorite tonalite), IG_BH03_SO005 (amphibolite) and IG_BH05_SO001 (diabase dyke)) collected from deep boreholes of the Revell Site in 3 reference groundwaters (CR-10, CR-10NF and CR-0). CR-10 simulates groundwater chemical conditions at repository depth in Canadian crystalline rock (600 to 800 m). CR-10NF is the reference groundwater after CR-10 is equilibrated with bentonite and carbon-steel container. CR-0 simulates groundwater chemical conditions in the shallow flow system of Canadian crystalline rock.

The sorption kinetics of Se, Tc, Np and Eu on core samples IG_BH01_SO001 and IG_BH05_SO001 and that of U on IG_BH01_SO014, IG_BH03_SO005 and IG_BH05_SO001 were measured in CR-10 (under both oxidizing and reducing conditions), CR-10NF (under reducing conditions), and CR-0 solutions (under both oxidizing and reducing conditions). Based on the sorption kinetics measurements, the sorption measurement periods were set to 2 weeks for Se(IV/VI), Se(-II), Np(V), Np(IV), U(VI) and U(IV) on all the five core samples, and Tc(IV), Tc(VII) and Eu(III) on IG_BH05_SO001; and 1 week for Tc(VII), Tc(IV) and Eu(III) on IG_BH01_SO001, IG_BH01_SO014, IG_BH03_SO002 and IG_BH03_SO005.

The values of sorption coefficient (K_d) of Se, Tc, Np, U and Eu for 5 core samples were measured in CR-10 under both oxidizing and reducing conditions, in CR-10NF under reducing conditions, and in CR-0 solution under oxidizing and reducing conditions.

The K_d values of Se(IV/VI), Se(-II), Tc(VII), Tc(IV), Np(V), Np(IV), U(VI), U(IV) and Eu(III) measured on IG_BH03_SO005 (amphibolite) were about twice as large as their K_d values measured on IG_BH01_SO001, IG_BH01_SO014 and IG_BH03_SO002 (biotite granodiorite tonalite).

The K_d values of Se(IV/VI), Se(-II), Tc(VII), Np(IV) and Eu(III) measured on IG_BH05_SO001 (diabase dyke) were about one half of the K_d values measured on IG_BH01_SO001, IG_BH01_SO014 and IG_BH03_SO002 (biotite granodiorite tonalite), but the differences of the K_d values for Tc(IV), Np(V), U(VI) and U(IV) measured on the diabase dyke core sample (IG_BH05_SO001) and on the biotite granodiorite tonalite core samples (IG_BH01_SO001, IG_BH01_SO014 and IG_BH03_SO002) were very small. This is likely because of higher biotite and chlorite contents in amphibolite rather than in biotite granodiorite tonalite and the diabase dyke.

The effect of the oxidation state on sorption is found to be significant for Tc, Np and U. K_d values of U, Tc and Np under reducing conditions are about 100, 1000 and 1000 times larger than that under oxidizing conditions for the 3 rock types tested, respectively. K_d values of Se under reducing conditions are larger than that under oxidizing conditions, but the difference is small.

All K_d values measured in this work were consistent with those compiled in the JAEA (Japan

Atomic Energy Agency) Sorption Database.

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1. INTRODUCTION

The Initial Borehole Drilling and Testing project in the Wabigoon and Ignace Area, Ontario is part of Phase 2 Geoscientific Preliminary Field Investigations for the Nuclear Waste Management Organization (NWMO)'s Adaptive Phased Management (APM) Site Selection Phase.

This project involves measuring sorption properties of four key redox sensitive radionuclides (Se, Np, Tc and U) and Eu (Eu is a chemical analogue for Pu(III)) for 5 rock core samples collected from three boreholes IG_BH01, IG_BH03 and IG_BH05 in the Revell Site within the identified potential Repository Area as shown on Figure 1-1.

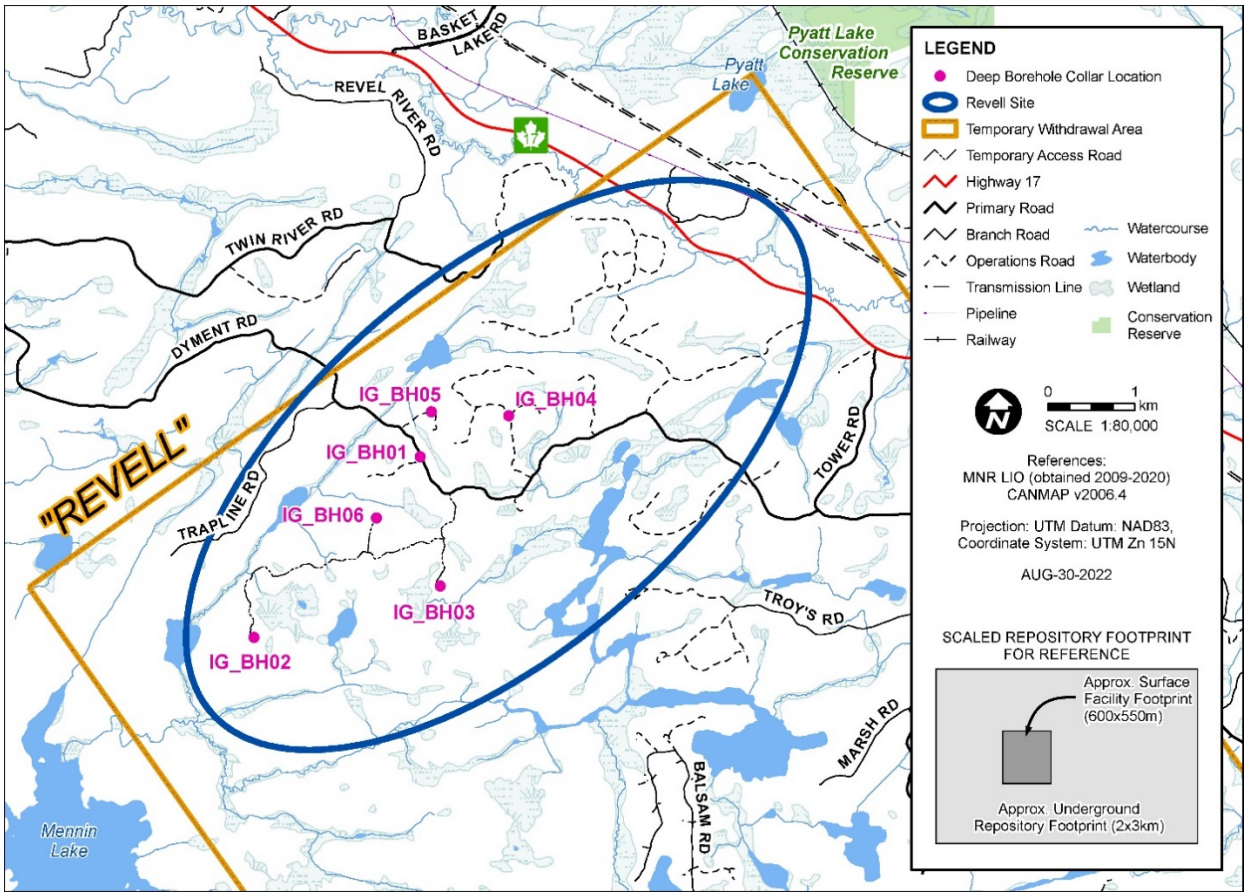


Figure 1-1: Location of IG_BH01, IG_BH03 and IG_BH05 in relation to the Revell Site

This report describes the testing methodology and results for measurement of sorption distribution coefficient (K_d) values of Se, Np, Tc, U and Eu for two core samples collected from IG_BH01, two core samples from IG_BH03, and one core sample from IG_BH05. The sorption measurements were conducted in three reference groundwaters, CR-10, CR-10NF and CR-0, under both oxidizing and reducing conditions. Reference groundwater CR-10 simulates groundwater chemical conditions at repository depth (600-800 m) in Canadian crystalline rock. CR-10NF is the reference groundwater after CR-10 is equilibrated with bentonite and the carbon-steel container. CR-0 simulates groundwater chemical conditions in the shallow flow system of Canadian crystalline rock.

1.1 GEOLOGICAL SETTING

The approximately 2.7-billion-year-old Revell batholith is located in the western part of the Wabigoon Subprovince of the Archean Superior Province. The batholith is roughly elliptical in shape trending northwest, is approximately 40 km in length, 15 km in width, and covers an area of approximately 455 km^2. Based on recent geophysical modelling, the batholith has a relatively flat base that extends to depths of nearly 4 km in some regions (SGL 2015). The batholith is surrounded by supracrustal rocks of the Raleigh Lake (to the north and east) and Bending Lake (to the southwest) greenstone belts (Figure 1-2).

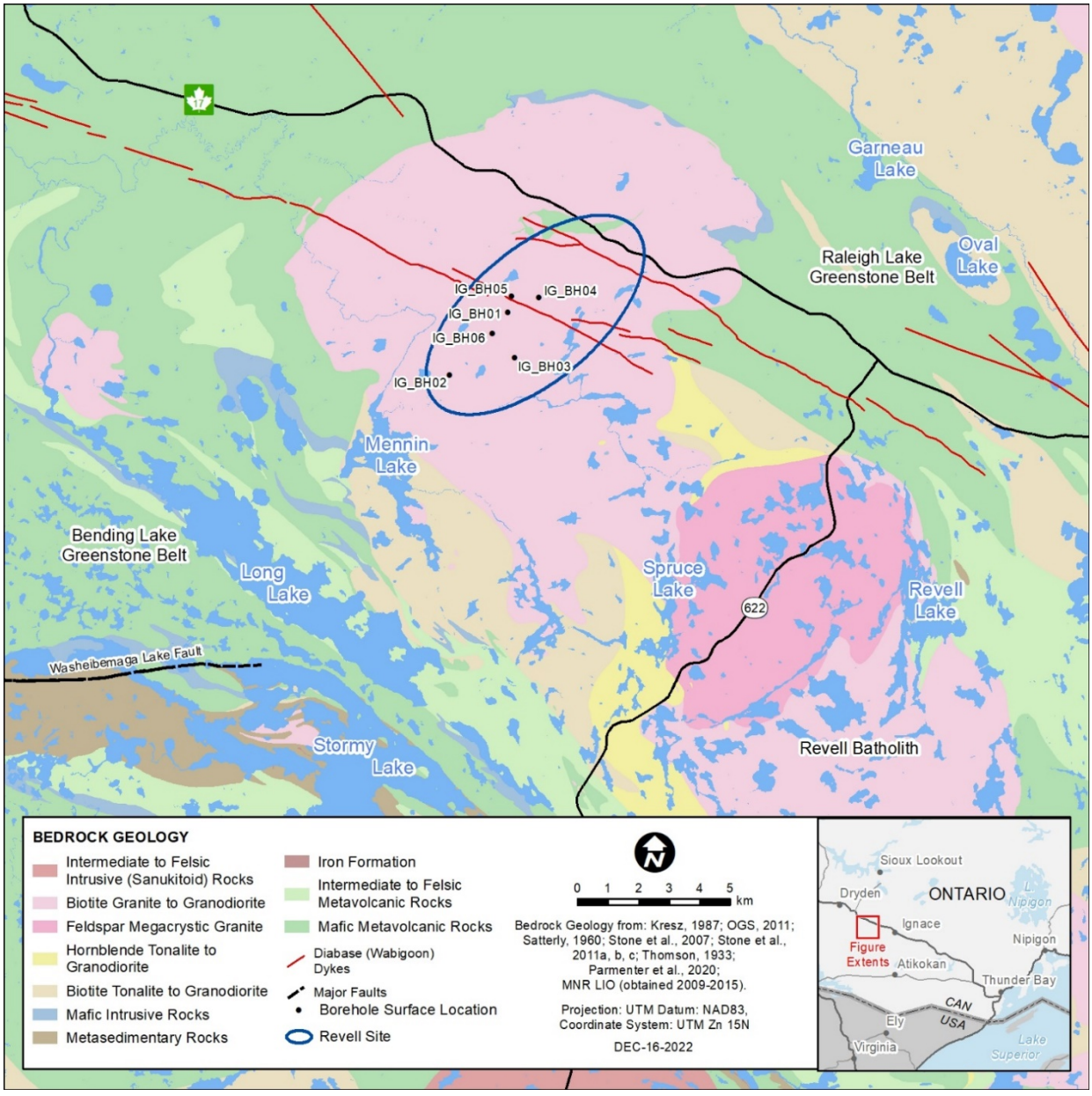


Figure 1-2: Location and geological setting of boreholes IG_BH01, IG_BH03 and IG_BH05 in the northern portion of the Revell batholith

Four main rock units are identified in the supracrustal rock group: mafic metavolcanic rocks, intermediate to felsic metavolcanic rocks, metasedimentary rocks and mafic intrusive rocks (Figure 1-2). Sedimentation within the supracrustal rock assemblage was largely synvolcanic, although sediment deposition in the Bending Lake area may have continued past the volcanic period (Stone 2009; Stone 2010a; Stone 2010b). All supracrustal rocks are affected, to varying degrees, by penetrative brittle-ductile to ductile deformation under greenschist- to amphibolite-facies metamorphic conditions (Blackburn and Hinz, 1996; Stone et al., 1998). In some locations, primary features, such as pillow basalt or bedding in sedimentary rock units are preserved. In other locations, primary relationships are completely masked by penetrative deformation. Uranium-lead (U-Pb) geochronological analysis of the supracrustal rocks produced ages that range between 2734.6 +/-1.1 Ma and 2725 +/-5 Ma (Stone et al. 2010).

Three main suites of plutonic rock are recognized in the Revell batholith (Figure 1-2), including, from oldest to youngest: a Biotite Tonalite to Granodiorite suite, a Hornblende Tonalite to Granodiorite suite, and a Biotite Granite to Granodiorite suite. Plutonic rocks of the Biotite Tonalite to Granodiorite suite occur along the southwestern and northeastern margins of the Revell batholith. The principal type of rock within this suite is a white to grey, medium-grained, variably massive to foliated or weakly gneissic, biotite tonalite to granodiorite. One sample of foliated and medium-grained biotite tonalite produced a U-Pb age of 2734.2+/-0.8 Ma (Stone et al. 2010). The Hornblende Tonalite to Granodiorite suite occurs in two irregularly shaped zones surrounding the central core of the Revell batholith. Rocks of the Hornblende Tonalite to Granodiorite suite range compositionally from tonalite through granodiorite to granite and also include significant proportions of quartz diorite and quartz monzodiorite. One sample of coarse-grained grey mesocratic hornblende tonalite produced a U-Pb age of 2732.3+/-0.8 Ma (Stone et al. 2010). Rocks of the Biotite Granite to Granodiorite suite underlie most of the northern, central and southern portions of the Revell batholith. Rocks of this suite are typically coarse-grained, massive to weakly foliated, and white to pink in colour. The Biotite Granite to Granodiorite suite ranges compositionally from granite through granodiorite to tonalite. This suite includes the oval-shaped potassium-feldspar megacrystic granite body in the central portion of the Revell batholith. One sample of coarse-grained, pink, massive potassium feldspar megacrystic biotite granite produced a U-Pb age of 2694.0+/-0.9 Ma (Stone et al. 2010).

IG_BH01, IG_BH03 and IG_BH05 are located in the northern portion of the Revell batholith, inside the Biotite Granite to Tonalite plutonic suite (Figure 1-2). Bedrock exposure in this part of the batholith is generally very good due to minimal overburden, few water bodies, and relatively recent forestry activities. The bedrock surrounding IG_BH01, IG_BH03 and IG_BH05 is composed mainly of massive to weakly foliated felsic intrusive rocks that vary in composition between granodiorite and tonalite. Bedrock identified as tonalite transitions gradationally into granodiorite and no distinct contact relationships between these two rock types are typically observed (SRK and Golder, 2015; Golder and PGW 2017). Massive to weakly foliated granite is identified at the ground surface to the southeast of the investigation area. The granite is observed to intrude into the granodiorite-tonalite bedrock, indicating that it is a distinct, younger intrusion (Golder and PGW 2017).

A west-northwest trending mafic dyke interpreted from aeromagnetic data and observed during detailed mapping to be approximately 15-20 m wide, extends across the northern portion of the batholith (Figure 1-2; Golder and PGW 2017). This dyke is associated with several other similarly-oriented mafic dykes that stretch across the northern portion of the Revell batholith and into the surrounding greenstone belts. All of these mafic dykes have a similar character and are interpreted to be part of the Wabigoon dyke swarm. One sample from the same Wabigoon swarm produced a U-Pb age of 1887+/-13 Ma (Stone et al. 2010), indicating that these mafic

dykes are Proterozoic in age. It is assumed based on surface measurements that these mafic dykes are sub-vertical (Golder and PGW 2017).

Locally, bedrock is well exposed near IG_BH01, IG_BH03 and IG_BH05 outcropping through a thin layer of overburden material and a few small wetlands (Figure 1-2). The exposed outcrops tend to form elongate linear ridges that have a dominant strike orientation towards the northeast. These ridges are described in DesRoches et al (2018) as northeast trending short and discontinuous linear valleys that may represent the surface expression of structural features that extend into the bedrock.

Regional observations from mapping have indicated that fractures tend to be widely spaced (typical 30 to 500 cm spacing range) and dominantly comprised of sub-vertical joints with two dominant orientations trending northeast and northwest (SRK and Golder 2015; Golder and PGW 2017). These fracture orientations generally follow the same dominant orientations of brittle lineaments in the northern portion of the Revell batholith (DesRoches et al., 2018). Minor subhorizontal joints have been mapped with minimal alteration, suggesting they are younger and perhaps related to glacial unloading. One mapped regional-scale fault, the Washeibemaga Lake fault, trends east and is located to the west of the Revell batholith (Figure 1-2). Additional details of the lithological units and structures found at surface in the northern portion of the Revell batholith are provided in Golder and PGW (2017).

2. EXPERIMENTAL METHODS

2.1 ROCK SAMPLE PREPARATION

The core samples were collected during drilling of the crystalline rock mass. Two rock core samples were collected from IG_BH01 (sample ID: IG_BH01_SO001, IG_BH01_SO014), two rock core samples were collected from IG_BH03 (sample ID: IG_BH03_SO002, IG_BH03_SO005), and one core sample was collected from IG_BH05 (sample ID: IG_BH05_SO001).

Each core sample was placed in a PVC bag within 15 to 30 minutes of core retrieval from the boreholes. The sample bag was then flushed with nitrogen and subsequently evacuated and heat-sealed. The sealed package was placed in a second PVC bag, similarly flushed with nitrogen and heat-sealed, and then the sample package was placed into a final plastic-coated Al-foil bag. After sealing, the samples were labelled and immediately stored under refrigerated conditions. The core samples were stored at NWMO's warehouse in Ignace under refrigerated conditions (approximately 4°C) until they were shipped to McMaster University in a cooler with dry ice under chain of custody protocols.

After the core samples arrived at the laboratory of McMaster University, they were stored in a refrigerator until use.

The information for the five rock core samples, including the rock types and the depths of the core samples collected from the boreholes, is summarized in Table 2-1.

Table 2-1: Rock Types and Depths of Core Samples

Borehole	Core sample ID	Rock type	Core sample depth (m bgs)
BH01	IG_BH01_SO001	biotite granodiorite tonalite	444.65 – 444.85
BH01	IG_BH01_SO014	biotite granodiorite tonalite	490.40 – 490.50
BH03	IG_BH03_SO002	biotite granodiorite tonalite	464.06 – 464.21
BH03	IG_BH03_SO005	amphibolite	548.52 – 548.65
BH05	IG_BH05_SO001	diabase dyke	299.51 – 299.99

The photos of the five core samples are shown in Figure 2-1.

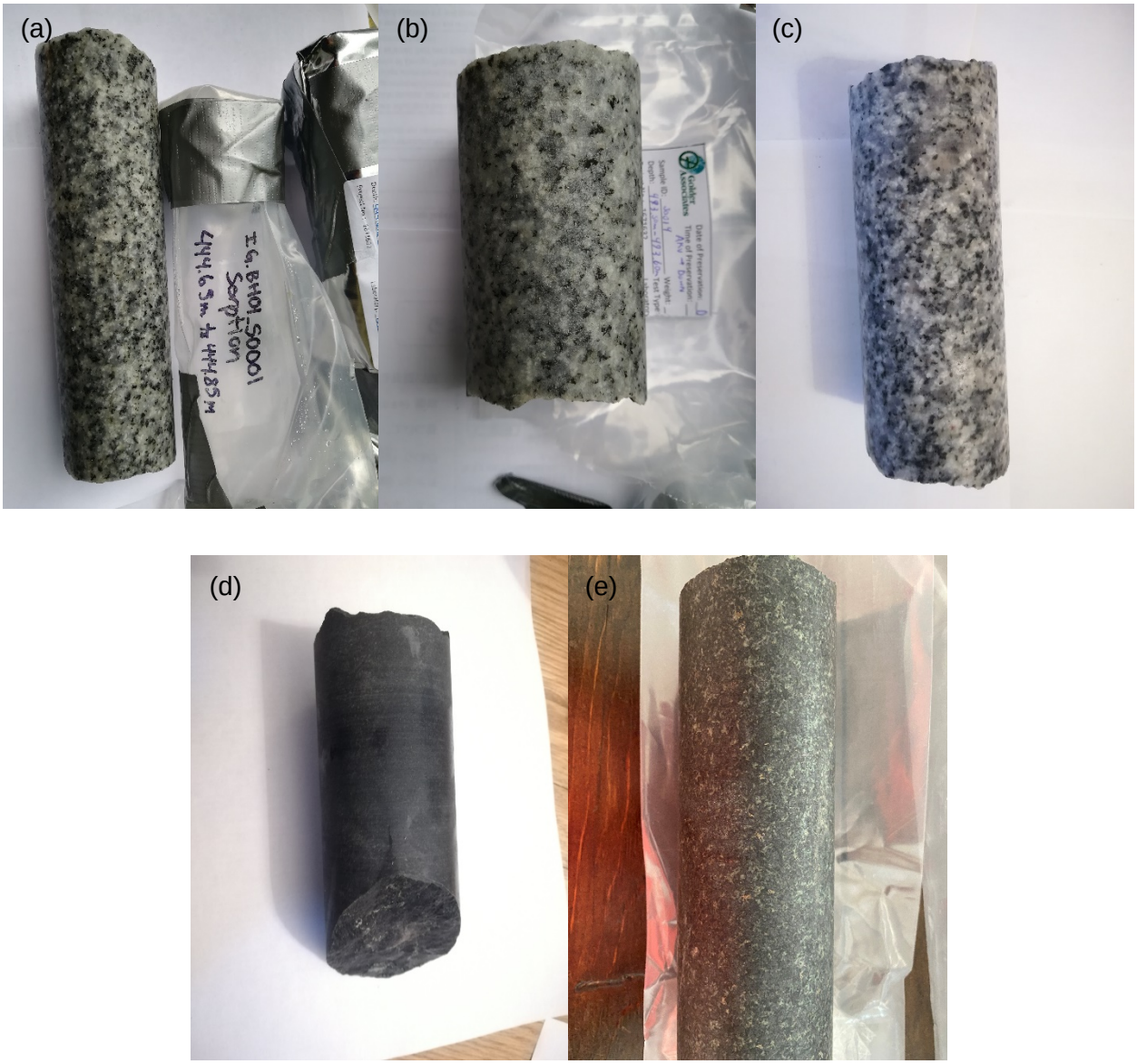


Figure 2-1: Photos of (a) IG_BH01_SO001 (biotite granodiorite tonalite), (b) IG_BH01_SO014 (biotite granodiorite tonalite), (c) IG_BH03_SO002 (biotite granodiorite tonalite), (d) IG_BH03_SO005 (amphibolite), and (e) IG_BH05_SO001 (diabase dyke)

Preparation of core samples for sorption testing followed the method described in Tanaka et al. (1989), as follows:

1) The crystalline rock core sample was first roughly crushed within the sample bag.
2) A roughly crushed sample was put into the “super hard cylinder mortar” of Nichika, which is made of tungsten carbide (http://www.nichika-kyoto.com/product/hasai/prod_4.html) and was then crushed in the cylinder mortar.

3) Crushed rock core samples were sieved using stainless steel sieves in deionized water, prepared using a Milli-Q Ultra-pure water system (DW). Mesh sizes of sieves included: 500 µm, 300 µm and 150 µm.
4) The sieved samples between 150 µm and 300 µm were collected and used for sorption measurements.

The mesh sizes were selected for practical reasons:

1) To allow for separation of the solid from the liquid;
2) To ensure representativeness of bulk solid properties; and
3) To minimize the release of smaller particles during the sorption experiments.

2.2 CR-10, CR-10NF AND CR-0 SOLUTION PREPARATION

Sorption testing was conducted using 3 reference groundwaters CR-10, CR-10NF and CR-0. CR-10 simulates the groundwater chemical conditions in crystalline rock at the repository depth in the Canadian Shield (Ca-Na-Cl type water with a TDS concentration of 11.3 g/L). CR-10NF simulates the groundwater chemical conditions after CR-10 is in equilibrium with bentonite and carbon steel container (Ca-Na-Cl type water with a TDS concentration of 17.8 g/L). CR-0 simulates the shallow groundwater chemical conditions in crystalline rock in the Canadian Shield (Na-Ca-HCO_3 type water with a TDS of 0.455 g/L).

The chemical compositions of CR-10, CR-10NF and CR-0 reference groundwaters provided by the NWMO are shown in Table 2-2.

Reagent grade chemicals and deionized water, prepared using a Milli-Q Ultra-pure water system to achieve a resistance of 18.2 milliohm/cm, were used to prepare the CR-10, CR-10NF and CR-0 solution.

CR-10, CR-10NF and CR-0 solutions were prepared using the following procedures:

1) Based on the chemical compositions of CR-10, CR-10NF and CR-0 shown in Table 2-2, the mass of chemical compounds used to prepare 1 L of CR-10, CR-10NF and CR-0 solutions was calculated and weighed out (see Table 3-1).
2) Each chemical compound was transferred to a 1 L volumetric flask.
3) Deionized water was added to the flask to bring the final volume to 1 L.
4) The flask was shaken well, and the solution was transferred to a 1 (L) polypropylene bottle.
5) It was verified that the solution was stable and no precipitates/residues settled to the bottom of the bottle.
6) pH and Eh of the solution were measured and recorded.
7) The solution was stored in a glove box filled with N_2 gas (99.999%).
8) The concentration of solutes was confirmed to be within ± 90 % of compositions shown in Table 2-2 by calculation or by measurement. pH of 6.5-7.5 for CR-10, 8-9.5 for

CR-10NF and 7-8 for CR-0 were confirmed. If the pH value of the solution was not within the specified range, the pH was adjusted using HCl or NaOH solution.

9) For solutions used for sorption experiments under reducing conditions, a small amount of reducing agent (hydrazine monohydrate) was added to achieve the reducing conditions for CR-10 and CR-10NF. This was because no redox couple was included in the compositions, and it was impossible to achieve the low Eh conditions without a reducing agent. If sodium dithionate is used to maintain the reducing conditions, it will degrade the surface of core samples under acidic and near-neutral conditions. The formation of Tc(IV) colloids may be promoted by the presence of this S-containing reagent. In addition, a strong reducing agent may change the Fe(II)/Fe(III) ratios of granite (i.e., increase the Fe(II) fraction in the investigated granitic materials). Therefore, we selected hydrazine monohydrate in this project.
10) The solution was centrifuged just before use for the sorption experiment.

The mass of chemical compounds used to establish CR-10, CR-10NF and CR-0 reference groundwaters is discussed in Section 3.1 (Table 3-1).

Table 2-2: CR-10, CR-10NF and CR-0 Reference Groundwater Compositions

Water Name	**CR-10**	**CR-10NF**	**CR-0**
Nominal pH	7.0	8.7	7.0
Redox state	Reducing	Reducing	Oxidizing
Nominal Eh (mV)	-200	-575	90
Solutes	**Concentration (mg/L)**		
Na	1,900	6,255	75
K	15	80	3
Ca	2,130	870	40
Mg	60	182	10
HCO_3	70	4	230
SO_4	1,000	4,314	50
Cl	6,100	6,059	40
Sr	25	25	<1
F	2	2	2
Si	5	10	5
Fe	1	7	0.01
TDS (mg/L)	11,300	17,810	455
Water type	Ca-Na-Cl	Na-Ca-Cl	Na-Ca-HCO_3

Note: Minor ions of F, Si, and Fe are excluded from the experiments in this work.

2.3 STOCK SOLUTION PREPARATION

Tracer standard solutions of Se and Eu were the solution purchased from the supplier (Agilent). Np-237 standard solution was purchased from Stuart Hunt & Associates Ltd. Tracer standard solution of Tc and U were obtained from McMaster University.

Tracer stock solution was the solution prepared from the tracer standard solution by adjustment of the oxidation state and or dilution to a certain concentration. The stock solution was stored in

a precise Controlled Atmosphere Glove Box which was filled with N_2 gas (> 99.999 %) (hereafter, GB).

A small volume of the tracer stock solution was used to spike the experimental solution so that the tracer concentration in the experimental solution (i.e., element initial concentration used in the sorption measurement) was less than the solubility of the tracer element.

2.3.1 Se Stock Solution Preparation

Se is a redox sensitive element predominantly existing in the redox states -II, IV and VI. Se(-II) (as HSe^-) prevails under reducing conditions, whereas Se(IV) (as SeO_3^{2-} or $HSeO_3^-$) and Se(VI) (as SeO_4^{2-}) dominate under oxidant conditions. Sorption of Se was measured under both oxidizing and reducing conditions.

2.3.1.1 Se(IV/VI) Stock Solution

Se(IV, VI) stock solution was prepared as follows:

1) Se standard solution (1,000 μg/mL, 100 mL) was purchased from Agilent.
2) Since the oxidation state of Se in the Se standard solution purchased from Agilent was a mixture of Se(IV) and Se(VI), the oxidation state of Se(IV/VI) did not need to be adjusted by additional treatment.
3) The concentration of Se in the Se standard solution was diluted by deionized water (DW), HCl or NaOH solution to $1x10^{-4}$ mol/L at pH = 2-3, which is lower than the solubility of Se(IV/VI). This was used as the Se(IV//VI) stock solution.

2.3.1.2 Se(-II) Stock Solution

Se(-II) stock solution was prepared as follows:

1) The concentration of Se in the Se standard solution purchased from Agilent was diluted to $1x10^{-4}$ mol/L by DW, HCl or NaOH solution. This was lower than the solubility of Se(-II).
2) Hydrazine monohydrate was added to the Se solution (Iida et al. 2011).
3) Since there was a possibility that Se(0) was produced by adding hydrazine monohydrate, the concentration of Se was measured before and after centrifugation to confirm that there was no precipitate of Se(0). If there were concentration differences before and after the centrifugation which could indicate the presence of precipitate of Se(0), only supernatant (Se(-II)) was planned to be used as the Se(-II) stock solution. But, in the actual measurements, the concentration difference was not observed.
4) The confirmed solution was used as the Se(-II) stock solution.

2.3.2 Tc Stock Solution Preparation

Tc is a redox sensitive element which may exist in several oxidation states (II to VII). In the reducing groundwater conditions, Tc(IV) will be predominant (e.g., $TcO(OH)_2$). In the oxidizing

groundwater conditions, Tc(VII) (as TcO_4^-) will be predominant. Sorption of Tc was measured under both oxidizing and reducing conditions.

2.3.2.1 Tc(VII) Stock Solution

1) Tc-99 standard solution which is stored at McMaster University was used in the sorption experiments. The oxidation state of Tc in the stored solution is Tc(VII), and the concentration is $1x10^{-2}$ mol/L.
2) The oxidation state of Tc in the stored solution was not adjusted by additional treatment. The concentration of Tc was diluted to $1x10^{-4}$ mol/L by DW, HCl or NaOH solution. This was used as the Tc(VII) stock solution.

2.3.2.2 Tc(IV) Stock Solution

1) Tc(VII) stock solution was electrolytically reduced to Tc(IV), according to the suggestion by Kobayashi and Takao (personal communications).
2) Since UV-Vis spectroscopy was not applicable to confirm the oxidation state of Tc, whether Tc was successfully reduced to (IV) was confirmed by the concentration of Tc in the liquid phase, which should be consistent with the solubility of Tc(IV).
3) The supernatant of Tc(IV) solution was sampled after centrifugation and the concentration of Tc(IV) was diluted to $1x10^{-7}$ mol/L. This was used as the Tc(IV) stock solution. This step was conducted just prior to the sorption experimental measurements. According to Kobayashi (personal communication), if Tc(IV) is oxidized during the centrifugation, the concentration of Tc in the supernatant may increase due to the dissolution of TcO_2(solid) (the solubility of Tc(VII) is significantly higher than that of Tc(IV)). Therefore, the oxidation of Tc(IV) to Tc(VII) could be easily detected.

2.3.3 Np Stock Solution Preparation

Np is a redox sensitive actinide element that may present different oxidation states depending on the redox conditions of the surrounding environment (III, IV, V, VI). Np(IV) is the most relevant oxidation state under groundwater reducing conditions (e.g., $Np(OH)_4$), whereas Np(V) is dominant under groundwater oxidizing conditions (e.g., NpO_2^+). Sorption of Np was measured under both oxidizing and reducing conditions.

2.3.3.1 Np(V) Stock Solution

Purchased Np in HNO_3 solution may contain Np(IV), Np(V) and Np(VI). Pure Np(V) in $HClO_4$ solution was prepared by the following procedures (Nagasaki 2018):

1) Np in HNO_3 solution was fed to an evaporation glass plate.
2) Np solution was evaporated and dried in the evaporation glass plate.
3) The Np dried in Step 2 was dissolved in a mixture of concentrated HNO_3 and concentrated $HClO_4$ solutions (HNO_3 : $HClO_4$ = 2 : 1 by volume ratio).

4) The Np solution prepared in Step 3 was evaporated and dried.
5) The dry Np prepared in Step 4 was dissolved in a mixture of concentrated HNO_3 and concentrated $HClO_4$ solutions (HNO_3 : $HClO_4$ = 2 : 1 by volume ratio).
6) The Np solution prepared in Step 5 was evaporated and dried.
7) The dry Np prepared in Step 6 was dissolved in 0.01 mol/L $HClO_4$ solution.
8) $HONH_3Cl$ was added to the Np solution prepared in Step 7 to stabilize the pentavalent oxidation state.
9) The oxidation state of Np prepared in Step 8 was confirmed to be pentavalent by the UV-VIS spectroscopic method.
10) The concentration of the Np(V) solution was adjusted to $1.0x10^{-3}$ mol/L.

2.3.3.2 Np(IV) Stock Solution

Pure Np(IV) stock solution in 0.01 mol/L $HClO_4$ solution was prepared by the following procedures (Nagasaki 2018):

1) Np(V) in 0.1 mol/L $HClO_4$ solution was prepared, according to the procedures described in Section 2.3.3.1. However, 0.1 mol/L $HClO_4$ was used instead of 0.01 mol/L $HClO_4$ (step 7 in Section 2.3.3.1), and $HONH_3Cl$ was not added (step 8 in Section 2.3.3.1).
2) 10% H_2 + 90% N_2 gas was flown through the Np(V) solution with Pt(Pt) (platinum black) catalyst in the fume hood for 12 hours (6 hours in the first day and 6 hours in the second day).
3) The oxidation state of Np was spectroscopically measured. Confirm that Np was reduced to Np(IV) or to Np(III) and Np(IV), and that Np(V) was not detected.
4) Contact the Np solution with air in the fume hood for 30 min to oxide any Np(III) to Np(IV).
5) The oxidation state of Np was spectroscopically measured. Confirm that Np(IV) was properly prepared.
6) Np(IV) was purified and Np(V) was removed by 0.1 mol/L TTA-xylene extraction and 0.01 mol/L $HClO_4$ back-extraction.
7) The Np(IV) solution was stored in a N_2 (99.999 %) filled glove box.
8) The concentration of the Np(IV) solution in 0.01 mol/L $HClO_4$ was adjusted to $1.0x10^{-7}$ mol/L. This was the Np(IV) stock solution used in this work.

2.3.4 U Stock Solution Preparation

Uranium is a redox sensitive actinide element that may present different oxidation states (IV, V, VI), depending on the redox conditions of the surrounding environment. U(IV) is the most relevant oxidation state under groundwater reducing conditions (e.g., $U(OH)_4$), whereas U(VI) is dominant under groundwater oxidizing conditions (e.g., UO_2^{2+}). Sorption of U was measured under both oxidizing and reducing conditions.

2.3.4.1 U(VI) Stock Solution

1) A standard solution of natural uranium in HNO_3 solution which was stored at McMaster University was used in the sorption experiments. The oxidation state of U in the stored solution is U(VI), and the concentration is $1x10^{-3}$ mol/L.
2) The oxidation state of U in the stored solution was not adjusted by additional treatment. The concentration of U will be diluted to $1x10^{-5}$ mol/L using DW, HCl or NaOH solution. This will be used as U(VI) stock solution.

2.3.4.2 U(IV) Stock Solution

1) Electrolytic reduction was applied to an aliquot of the U(VI) stock solution described in Section 2.3.4.1.
2) Reduction of U(VI) to U(IV) was confirmed by measuring the total electric currents required for reduction of U(VI) to U(IV) (with the known concentration of U(IV). The ampere (A) needed to complete the reaction $UO_2^{2+} + 2e^- + 4H^+ \text{ --- > } U^{4+} + 2H_2O$ can be calculated) and/or by UV-Vis spectroscopy.
3) The supernatant of U(IV) solution was sampled after centrifugation and the concentration of U was diluted to $1x10^{-7}$ mol/L. This was used as U(IV) stock solution. This step was conducted just prior to the sorption experiments.

2.3.5 Eu Stock Solution Preparation

2.3.5.1 Eu(III) stock solution

1) Eu standard solution (1,000 µg/mL, 100 mL) was purchased from Agilent.
2) Since the oxidation state of Eu in the Eu standard solution purchased from Agilent is Eu(III), the oxidation state of Eu(III) does not need to be adjusted by additional treatment.

2.4 SORPTION COEFFICIENT CALCULATION

Sorption coefficient (K_d) was calculated by:

$$K_d = \frac{(C_0 - C_e)}{C_e}\frac{V}{W}$$

where C_0 is the initial concentration of Se, Tc, Np, U or Eu in the liquid phase of the solid liquid system, C_e is the equilibrium concentration of Se, Tc, Np, U or Eu in the liquid phase, V is the volume of the liquid phase, and W is the mass of the solid phase.

2.5 SORPTION MEASUREMENT

2.5.1 Experimental Set-up

The sorption experiments were conducted using batch tests in a glove box filled with highly purified N_2 gas in order to minimize CO_2 and O_2 contamination (for sorption experiments conducted both under reducing conditions and under oxidizing conditions). The O_2

concentration in highly purified N_2 gas was confirmed to be sufficiently low (less than 2 ppm) by an oxygen detector (Nagasaki 2018).

The batch tests were conducted using polycarbonate centrifuge tubes. Aliquots of rock core sample were put into the polycarbonate centrifuge tubes and the CR-10, CR-10NF or CR-0 solution was added for pre-conditioning of the solid for several days. After removing the liquid phase, the CR-10, CR-10NF or CR-0 solution (10 mL) and a small volume of Se(-II), Se(IV/VI), Tc(VII), Tc(IV), Np(IV), Np(V), U(VI), U(IV) or Eu(III) stock solution was added to the centrifuge tube to initiate the sorption tests. The pH of the solution in the centrifuge tube was measured. If necessary, pH of the solution was adjusted to the desired value by adding HCl or NaOH solution.

The time required to establish the sorption equilibrium was determined by sorption kinetics tests. Kinetics test were conducted for Se, Tc, Np and Eu with core samples IG_BH01_SO001 (biotite granodiorite tonalite) and IG_BH05_SO001 (diabase dyke) and for U with core samples IG_BH1_SO014 (biotite granodiorite tonalite), IG_BH03_SO005 (amphibolite) and IG_BH05_SO001 (diabase dyke).

The sorption sample tubes were prepared in the glove box. The sample tubes were tightly sealed in the glove box, before being gently shaken in an incubator (25^{o}C) installed outside of the glove box. Based on previous experience conducting Np sorption tests under reducing conditions (Tanaka et al. 1999; Nagasaki 2018), the oxidation of tracers by O_2(g) during the process is considered to be negligible.

Solid phases were separated from the liquid phase by centrifugation (for Se, Tc and Np) or ultracentrifugation (for U and Eu). This is because the sorption measurements for Se, Tc and Np were completed before the ultracentrifuge equipment was installed in the lab in 2021. The concentration of Se, Tc, Np, Eu and U in the liquid phase was measured using an ICP-MS. The solid/liquid separation and the concentration measurements were performed under atmospheric conditions in the laboratory.

Sorption sampling for concentration measurements for each different set of experimental conditions was conducted in triplicate. The errors in K_d values were evaluated, considering the scatter of triplicate sorption data and the precision of ICP-MS.

Detailed procedures for sorption measurements are described in the following sections.

2.5.2 Sorption Measurements for Se

2.5.2.1 Sorption Kinetics

Sorption kinetics of Se(IV/VI) under oxidizing conditions and that of Se(-II) under reducing conditions on IG_BH01_SO001 (biotite granodiorite tonalite) or IG_BH05_SO001 (diabase dykes) were measured to determine the sorption time to achieve the sorption equilibrium.

The optimized solid/liquid (*S*/*L*) ratio was decided according to: 1) the K_d values of Se(IV/VI) and Se(-II) for similar crystalline rock types compiled in the sorption database of Japan Atomic Energy Agency (JAEA) (https://migrationdb.jaea.go.jp/english.html); 2) the initial concentration of Se used in the sorption testing; and 3) the detection limit of the ICP-MS (Agilent ICP-MS 8800) for Se.

For the sorption experiments conducted under oxidizing conditions, the CR-10 and CR-0 solutions prepared for oxidizing conditions were used. For the sorption experiments conducted under reducing conditions, the CR-10, CR-10NF and CR-0 solutions prepared for reducing conditions were used (see discussion in Section 2.2 and Section 3.1).

The sorption kinetics experimental procedures for Se(IV/VI) (oxidizing condition) and Se(-II) (reducing condition) are as follows:

1) An amount of crushed rock core sample (150 - 300 μm), which was decided by the optimized *S*/*L* ratio, was added into a 15 mL centrifuge tube in a glove box filled with N_2 gas (99.999%).
2) 10 mL CR-10, CR-10NF or CR-0 solution was added into the centrifuge tube prepared in Step 1 in the glove box. In total, six sample tubes for each of the CR-10, CR-10NF and CR-0 solution were prepared.
3) Rock core sample/solution mixture stayed in the glove box for several days (approximately two to three days) for pre-equilibrium (pre-conditioning).
4) The centrifuge tubes were transferred to a centrifuge. The liquid was separated from the sorbent by centrifugation for 30 min at 12,000 rpm. The centrifuge tubes were transferred to the glove box and the liquid was removed using an adjustable pipette.
5) 10 mL solution was added into the centrifuge tube prepared in step 4 in the glove box.
6) The centrifuge tubes stayed in the glove box for approximately 24 hours.
7) A portion of Se(IV/VI) or Se(-II) stock solution prepared in Section 2.4.1 was spiked into the centrifuge tubes in the glove box. Se concentrations in the liquid were 10^{-8} mol/L. The centrifuge tubes were tightly sealed in the glove box.
8) The centrifuge tubes were transferred to an incubator at 25°C (Infors HT Ectron) and were shaken for pre-determined periods (1 day, 2 days, 3 days, 1 week, 2 weeks and 3 weeks).
9) After each pre-determined period, the liquid was separated from the solid by centrifugation for 30 minutes at 18,000 rpm at 25°C. The pH and Eh values of the liquid were measured in the glove box.
10) An aliquot (5 mL) was sampled from the liquid phase of each centrifuge tube. The concentration of Se in the aliquot was measured using ICP-MS in triplicate. The concentration of Se sorbed on the rock core sample was evaluated, and the K_d value and its error were calculated.

Based on the kinetics measurement results, the sorption equilibrium time was decided for each experimental condition (CR-10 (oxidizing and reducing), CR-10NF (reducing) or CR-0 solution (oxidizing and reducing)).

2.5.2.2 K_d Value Measurement

The K_d values of Se(IV/VI) under oxidizing conditions (for CR-10 and CR-0 solutions) and those of Se(-II) under reducing conditions (for CR-10, CR-10NF and CR-0 solutions) on rock core samples were measured following the optimized experimental procedures determined using the kinetic tests, as described in the previous section.

For the sorption experiments under oxidizing conditions, the CR-10 and CR-0 solutions prepared for oxidizing conditions were used. For those under reducing conditions, the CR-10, CR-10NF and CR-0 solutions prepared for reducing conditions were used.

The experimental procedures for Se(IV/VI) (oxidizing condition) and Se(-II) (reducing condition) sorption measurements are as follows:

1) An amount of rock core samples (150-300 μm), which was decided based on the optimized *S*/*L* ratio, was added into a 15 mL centrifuge tube in a glove box filled with N_2 gas (99.999%).
2) 10 mL CR-10, CR-10NF or CR-0 solution was added into the centrifuge tube prepared in Step 1 in the glove box.
3) Rock core sample/solution mixture stayed in the glove box for several days (approximately two to three days) for pre-equilibrium (pre-conditioning).
4) The centrifuge tube was transferred to centrifuge equipment and set in it. The liquid was separated from the sorbent by centrifugation for 30 min at 12,000 rpm. The centrifuge tube was transferred to the glove box and the liquid was removed by a pipette.
5) 10 mL solution was added into the centrifuge tube prepared in step 4 in the glove box.
6) The centrifuge tube stayed in the glove box for approximately 24 hours.
7) A portion of Se(IV/VI) or Se(-II) stock solution prepared in Section 2.3.1 was spiked into the centrifuge tubes in the glove box. Se concentrations in the liquid were 1×10^{-8} mol/L.
8) pH of the solution was adjusted to a value which was measured in sorption kinetics within ±0.5 pH unit. This value was recorded as the initial pH value.
9) The value of Eh of the solution was measured and recorded as the initial Eh value.
10) The centrifuge tube was tightly sealed in the glove box.
11) The centrifuge tubes were transferred to an incubator at 25°C (Infors HT Ectron) and were shaken for a period of sorption equilibrium time determined in sorption kinetics measurement.
12) After sorption equilibrium time, the liquid was separated from the solid by centrifugation for 30 minutes at 18,000 rpm at 25°C. The pH and Eh values of the liquid were measured in the glove box and recorded as final pH and Eh values.
13) An aliquot (5 mL) was sampled from the liquid phase of each centrifuge tube. The concentration of Se in the aliquot was measured using ICP-MS in triplicate. The concentration of Se sorbed on the rock core sample was evaluated, and the K_d value and its error were calculated.

2.5.3 Sorption Measurements for Tc

The experimental procedures for measuring Tc sorption kinetics and K_d values are the same as that for Se. Based on the preliminary test, the sorption kinetics was measured at 1 day, 2 days, 3 days, 1 week and 2 weeks for core sample IG_BH01_SO001 (biotite granodiorite tonalite). For core sample IG_BH05_SO001 (diabase dykes), the sorption kinetics was measured at 1 day, 2 days, 3 days, 1 week, 2 weeks and 3 weeks.

The initial concentrations of Tc(VII) (oxidizing condition) and Tc(IV) (reducing condition) in the sorption measurements were adjusted to 8×10^{-10} mol/L and 5×10^{-10} mol/L, respectively.

2.5.4 Sorption Measurements for Np

The experimental procedures for measuring Np sorption kinetics and K_d values were the same as that for Se.

The initial concentration of Np in the sorption measurements was adjusted to 1×10^{-11} mol/L for both Np(V) (oxidizing condition) and Np(IV) (reducing condition) sorption experiments.

2.5.5 Sorption Measurements for U

The experimental procedures for measuring U sorption kinetics and K_d values are the same as that for Se.

The initial concentrations of U(VI) (oxidizing condition) and U(IV) (reducing condition) in the sorption experiments were adjusted to 1×10^{-9} mol/L. Solid/liquid separation was done by ultracentrifugation (100,000 rpm for 15 min).

2.5.6 Sorption Measurements for Eu

The experimental procedures for measuring Eu sorption kinetics and K_d values are the same as that for Se.

The initial concentration of Eu was adjusted to 9×10^{-8} mol/L. Solid/liquid separation was done by ultracentrifugation (100,000 rpm for 15 min).

3. MEASUREMENT RESULTS

3.1 CR-10, CR-10NF AND CR-0 SOLUTION

The mass of chemical compounds used to prepare 1 L of CR-10, CR-10NF and CR-0 solutions are summarized in Table 3-1. All the element concentrations of the established experimental CR-10, CR-10NF and CR-0 solutions are within 90% of the original reference groundwater concentrations, as shown in Table 3-2. No precipitate was observed. The minor ions of F, Si and Fe are excluded from the sorption experiments in this work. For the solutions prepared for sorption experiments conducted under reducing conditions, a small amount of hydrazine monohydrate was added. 1 L of CR-10, CR-10NF and CR-0 experimental solutions were prepared. When the experimental solutions were used up, new experimental solutions were produced. The values of pH and Eh (vs. SHE) in Table 3-2 were those measured in the solutions prepared for the first time.

Table 3-1: Mass of Chemical Compounds Used to Prepare 1 L of CR-10, CR-10NF and CR-0 Solutions

Chemical compounds	Mass to prepare 1 L of solution (mg)
CR-10	
KCl	28.5
NaCl	4760
$CaCl_2 \cdot 2H_2O$	6270
$Mg(OH)_2$	145
$SrCl_2 \cdot 6H_2O$	76
$NaHCO_3$	96
$(CaSO_4)_2 \cdot H_2O$	1510
CR-10NF	
NaCl	100500
Na_2SO_4	3178
$(CaSO_4)_2 \cdot H_2O$	3200
NaOH	2350
$NaHCO_3$	5.4
$Mg(OH)_2$	440
K_2SO_4	180
$SrCl_2 \cdot 6H_2O$	77
CR-0	
$NaHCO_3$l	310
$CaCl_2 \cdot 2H_2O$	70
$(CaSO_4)_2 \cdot H_2O$	76
KCl	6
$Mg(OH)_2$	24

As shown in Table 2-2 and Table 3-2, the Eh value of the CR-10NF reference groundwater is -575 mV, but the Eh value of the established CR-10NF experimental solution was -220 mV. This is because the Eh in the CR-10NF reference groundwater is controlled by reaction of CR-10 with carbon steel, but in the experimental solution the reaction was with hydrazine. Because the

speciation of redox-sensitive elements (Se, Tc, Np and U) at Eh = -575 mV is the same as that at -200 mV, the sorption behaviour of Se, Tc, Np and U at Eh = -200 mV shown in this report is considered to be the same as that at Eh = -575 mV.

Table 3-2: CR-10, CR-10NF and CR-0 Compositions in Reference Groundwaters and Experimental Solutions

Solutes	**Concentration (mg/L)**	
CR-10	**Reference groundwater**	**Experimental solution**
Na	1,900	1,900
K	15	15
Ca	2,130	2,080
Mg	60	60
HCO_3	70	70
SO_4	1,000	1,000
Cl	6,100	5,950
Sr	25	25
pH/Eh (oxidizing)	-	6.7/360 mV
pH/Eh (reducing)	7.0/-200 mV	7.2/-210 mV
CR-10NF	**Reference groundwater**	**Experimental solution**
Na	6,255	6,300
K	80	81
Ca	870	884
Mg	182	184
HCO_3	4	4
SO_4	4,311	4,310
Cl	6,059	6,127
Sr	25	25
pH/Eh (reducing)	8.7/-575 mV	8.8/-220 mV
CR-0	**Reference groundwater**	**Experimental solution**
Na	75	75
K	3	3
Ca	40	40
Mg	10	10
HCO_3	230	235
SO_4	50	50
Cl	40	37
Sr	< 1	< 1
pH/Eh (oxidizing)	7.0/90 mV	7.3/320 mV
pH/Eh (reducing)	-	7.8/-230 mV

3.2 SELENIUM SORPTION

3.2.1 Sorption Kinetics

The sorption kinetics measurements of Se on core samples IG_BH_SO001 (biotite granodiorite tonalite) and IG_BH05_SO001 (diabase dyke) in CR-10, CR-10NF, and CR-0 experimental solutions under both reducing and oxidizing conditions are shown in Figure 3-1 and Figure 3-2, respectively. The solid/liquid ratio was 1 g/10 mL.

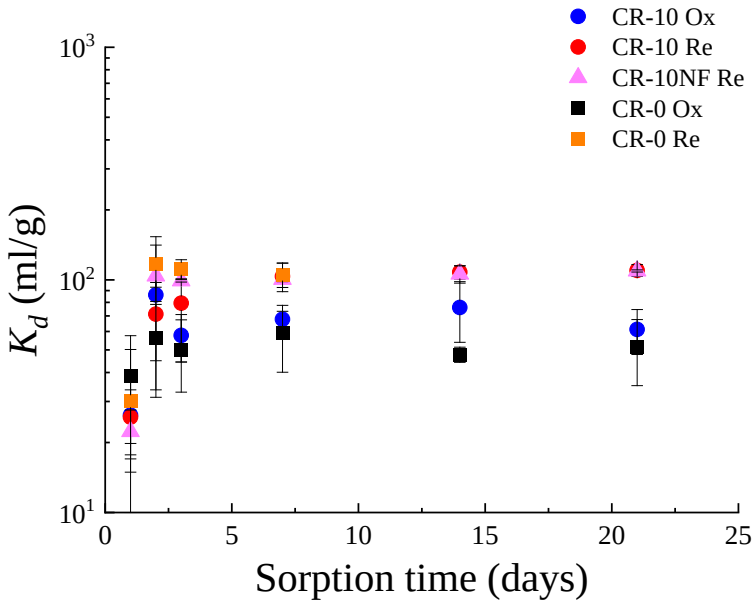


Figure 3-1: Sorption kinetics of Se on IG_BH01_SO001 (biotite granodiorite tonalite) in CR-10, CR-10NF and CR-0 experimental solutions under reducing and oxidizing conditions

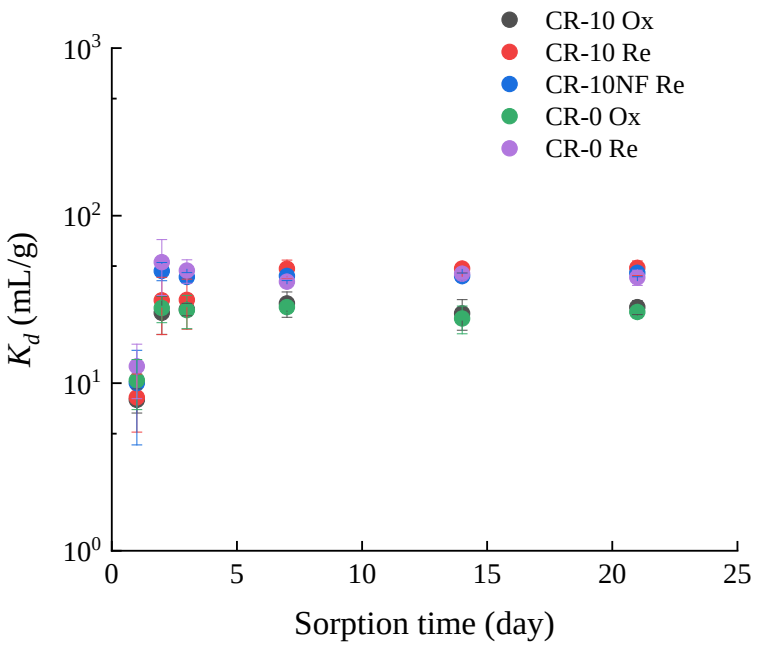


Figure 3-2: Sorption kinetics of Se on IG_BH05_SO001 (diabase dyke) in CR-10, CR-10NF and CR-0 solutions under reducing and oxidizing conditions

From these results, Se sorption was found to reach sorption equilibrium within 1 week in 3 experimental solutions under both reducing and oxidizing conditions. Hence, we decided to set 2 weeks for the sorption period of Se(IV, VI) and Se(-II) sorption in this report. The details of measurement data are summarized in the Appendix (Tables A-1 to A-10).

3.2.2 K_d Value Measurement

The measured K_d values are summarized in Figures 3-3 to 3-7. For IG_BH01_SO001 (biotite granodiorite tonalite) and IG_BH01_SO014 (biotite granodiorite tonalite), one test tube was prepared for each solution and the concentration in the tube was measured in triplicate. For IG_BH03_SO002 (biotite granodiorite tonalite), IG_BH03_SO005 (amphibolite) and IG_GH05_SO001 (diabase dyke), three tubes were prepared for each solution and the concentration in each tube was measured in triplicate.

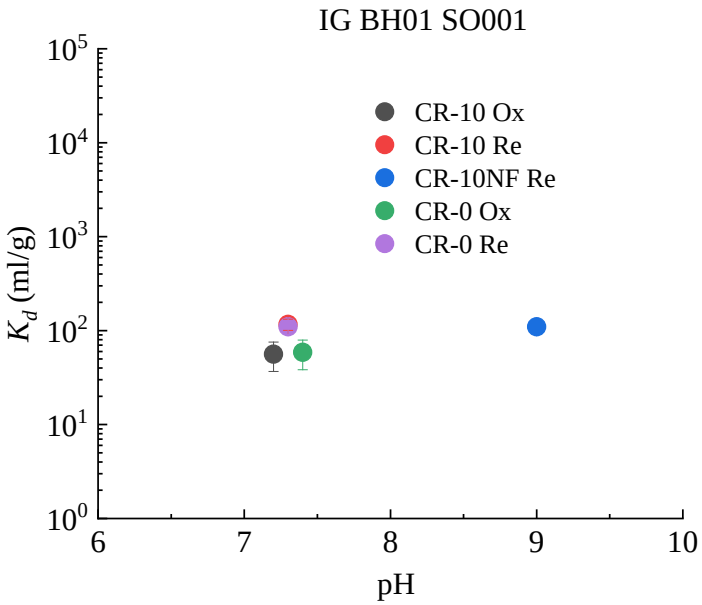


Figure 3-3: K_d values of Se on IG_BH01_SO001 (biotite granodiorite tonalite) in CR-10, CR-10NF and CR-0 solutions under reducing and oxidizing conditions

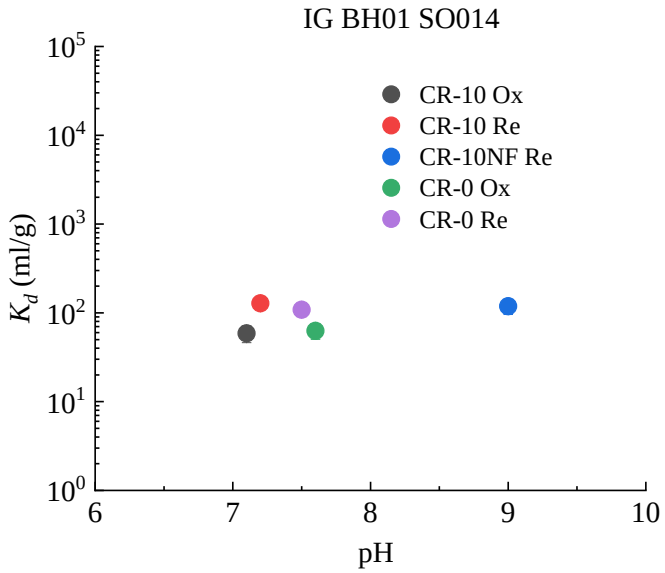


Figure 3-4: K_d values of Se on IG_BH01_SO014 (biotite granodiorite tonalite) in CR-10, CR-10NF and CR-0 solutions under reducing and oxidizing conditions

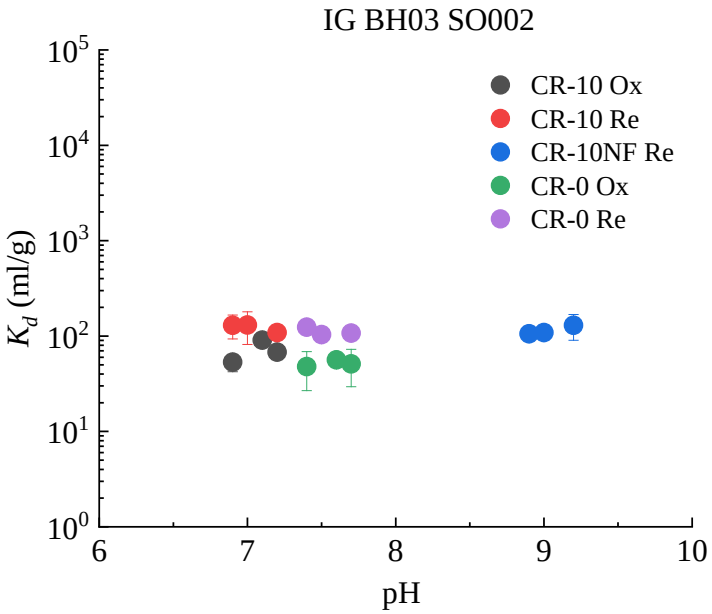


Figure 3-5: K_d values of Se on IG_BH03_SO002 (biotite granodiorite tonalite) in CR-10, CR-10NF and CR-0 solutions under reducing and oxidizing conditions

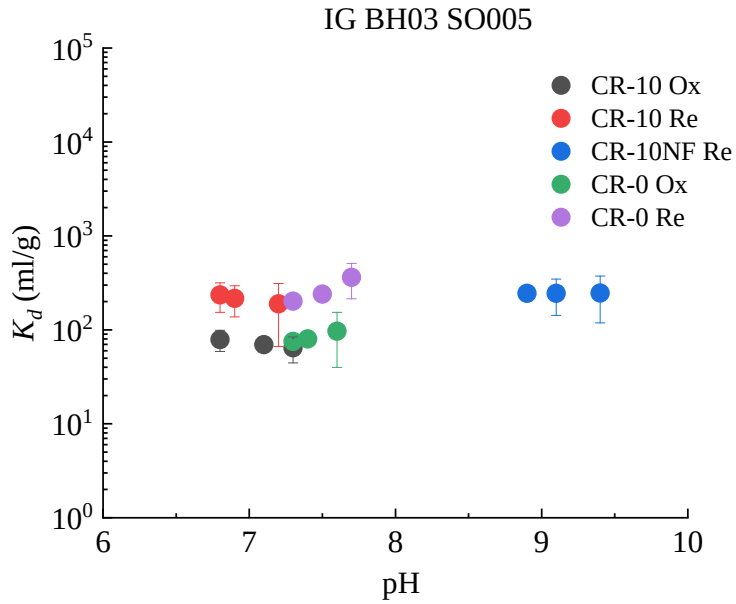


Figure 3-6: K_d values of Se on IG_BH03_SO005 (amphibolite) in CR-10, CR-10NF and CR-0 solutions under reducing and oxidizing conditions

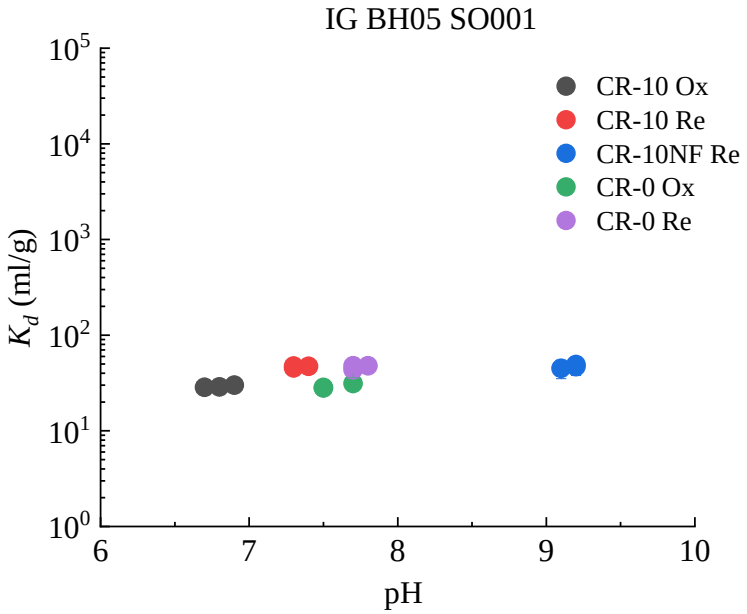


Figure 3-7: K_d values of Se on IG_BH05_SO001 (diabase dyke) in CR-10, CR-10NF and CR-0 solutions under reducing and oxidizing conditions

All K_d values of Se(-II) and Se(IV/VI) are summarized in Figures 3-8 and 3-9. The K_d values of Se(-II) measured on 3 biotite granodiorite tonalite core samples (IG_BH01_SO001, IG_BH01_SO014 and IG_BH03_SO002) are very similar to each other. The K_d values of Se(IV/VI) measured on 3 biotite granodiorite tonalite core samples are also very similar to each other. The K_d values of Se(-II) and Se(IV/VI) measured on the amphibolite core sample (IG_BH03_SO005) are nearly twice as large as their K_d values measured on the 3 biotite granodiorite tonalite core samples. The K_d values of Se(-II) and Se(IV/VI) measured on the diabase dyke core sample (IG_BH05_SO001) are about one half of their K_d values measured on the biotite granodiorite tonalite core samples. This is likely because of the higher biotite and chlorite contents in amphibolite than in biotite granodiorite tonalite and the diabase dyke. Overall, the K_d values of Se(-II) are larger than that of Se(IV/VI) for all core samples, but the effect of oxidation states on sorption of Se is small. On the other hand, the effect of mineral compositions of rock samples on sorption of Se is significant compared to the effect of the oxidation states. Furthermore, the effect of solution chemistry on sorption of Se is negligible. The measured data are summarized in the Appendix (Tables A-11 to A-15).

The K_d values of Se on granite compiled in the JAEA sorption database are shown in the Appendix (Figures A-1 and A-2). The K_d values obtained in this work are consistent with those compiled in the JAEA sorption database.

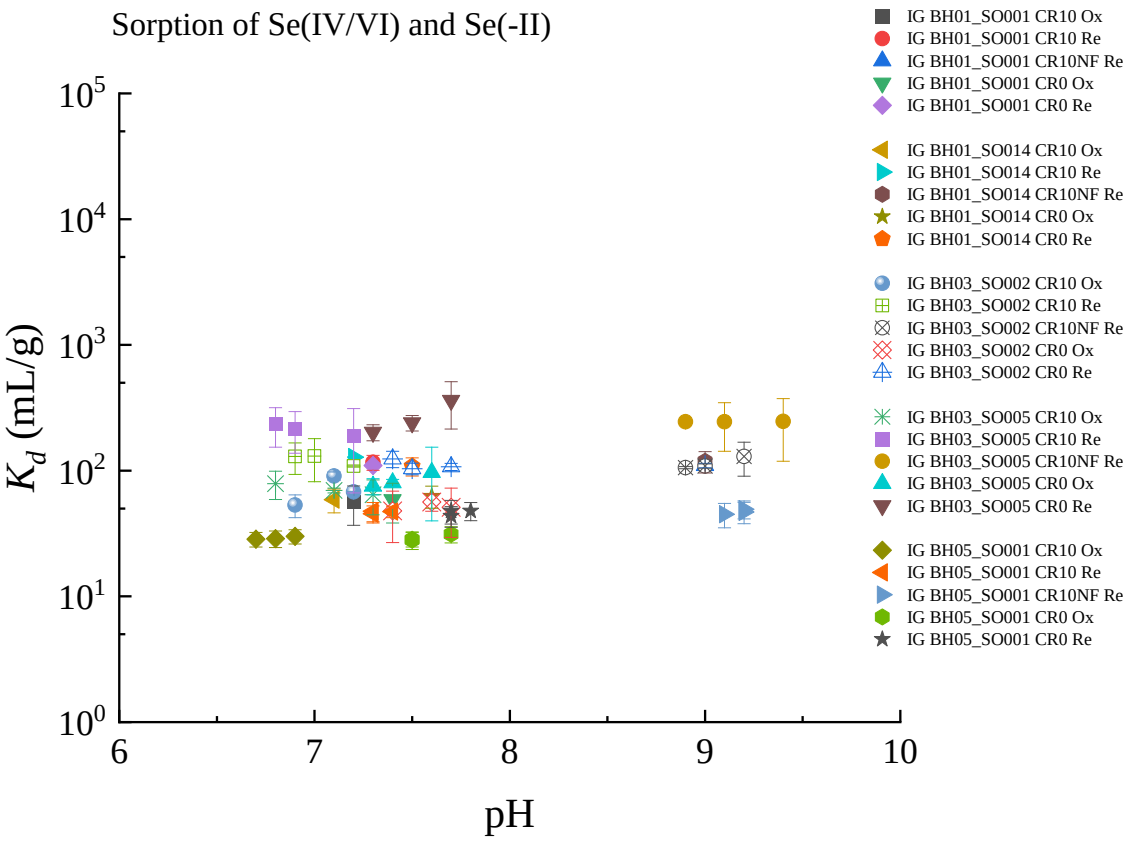


Figure 3-8: K_d values of Se on IG_BH01_SO001, IG_BH01_SO014, IG_BH03_SO002 (biotite granodiorite tonalite), IG_BH03_SO005 (amphibolite) and IG_BH05_SO001 (diabase dyke) in CR-10, CR-10NF and CR-0 solutions under reducing and oxidizing conditions

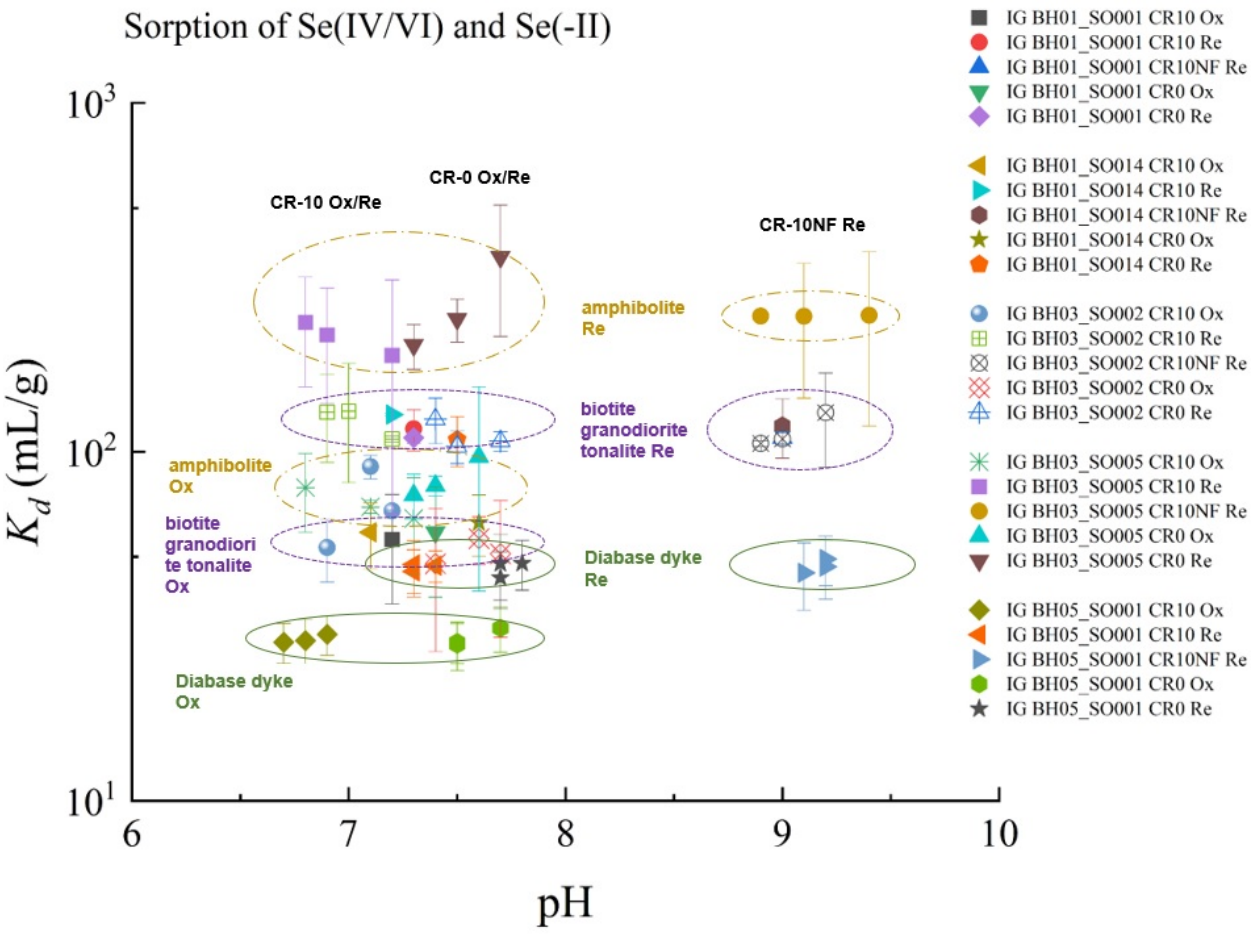


Figure 3-9: Dependence of Se K_d values on rock types (biotite granodiorite tonalite, amphibolite and diabase dyke) in CR-10, CR-10NF and CR-0 solutions under reducing and oxidizing conditions

3.3 TECHNETIUM SORPRTION

3.3.1 Sorption Kinetics

The sorption kinetics of Tc on IG_BH_SO001 (biotite granodiorite tonalite) and IG_BH05_SO001 (diabase dyke) are shown in Figure 3-10 and Figure 3-11, respectively. The solid/liquid ratio was set to 1 g/10 mL for Tc(VII) sorption under oxidizing conditions and 0.01 g/10 mL for Tc(IV) sorption under reducing conditions. Since large K_d value was expected for Tc(IV) sorption, the smaller solid/liquid ratio was used.

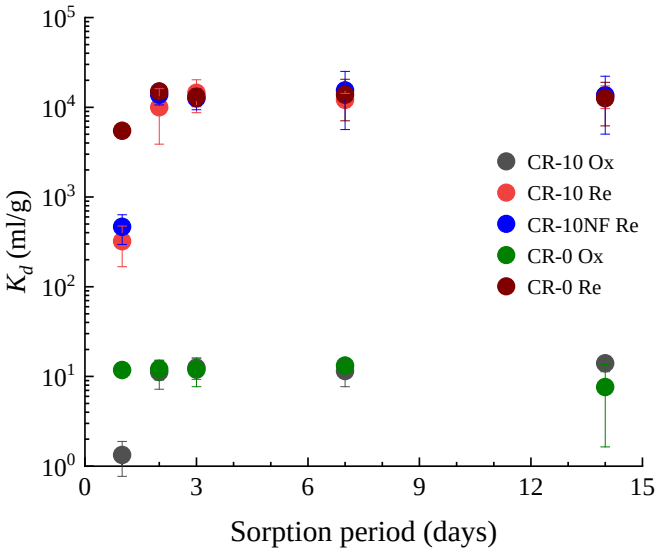


Figure 3-10: Sorption kinetics of Tc on IG_BH01_SO001 (biotite granodiorite tonalite) in CR-10, CR-10NF and CR-0 experimental solutions under oxidizing and reducing conditions

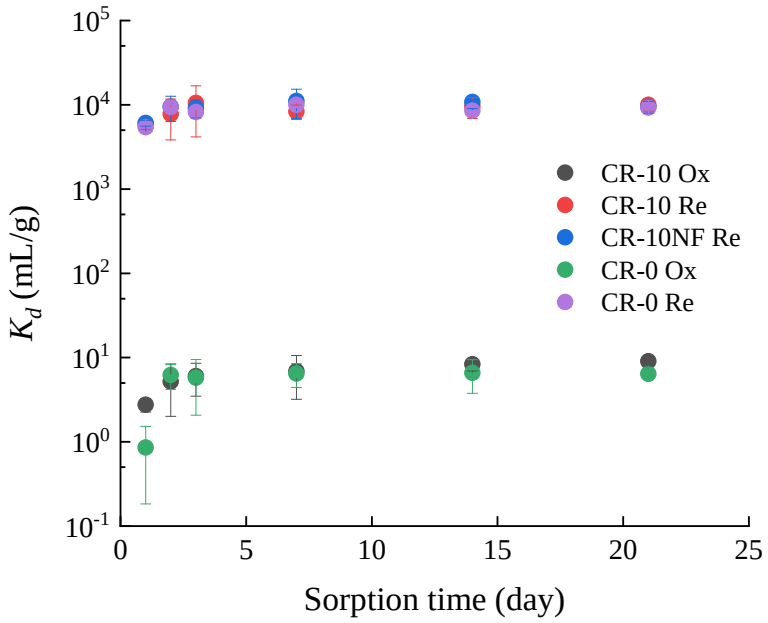


Figure 3-11: Sorption kinetics of Tc on IG_BH05_SO001 (diabase dyke) in CR-10, CR-10NF and CR-0 experimental solutions under oxidizing and reducing conditions

The sorption of Tc reached equilibrium within 3 days and 7 days for core samples IG_BH01_SO001 and IG_BH05_SO001, respectively. Hence, 1 week was set for the sorption reaction period for the Tc(VII) and Tc(VI) sorption batch tests on IG_BH01_SO001, IG_BH01_SO014, IG_BH03_SO002 and IG_BH03_SO005. 2 weeks were set for the sorption reaction period for Tc(VII) and Tc(VI) sorption batch tests on IG_BH05_SO001. Details of sorption kinetics of Tc are summarized in the Appendix (Tables A-16 to A-25).

3.3.2 K_d Value Measurement

The measured K_d values of Tc are summarized in Figures 3-12 to 3-16.

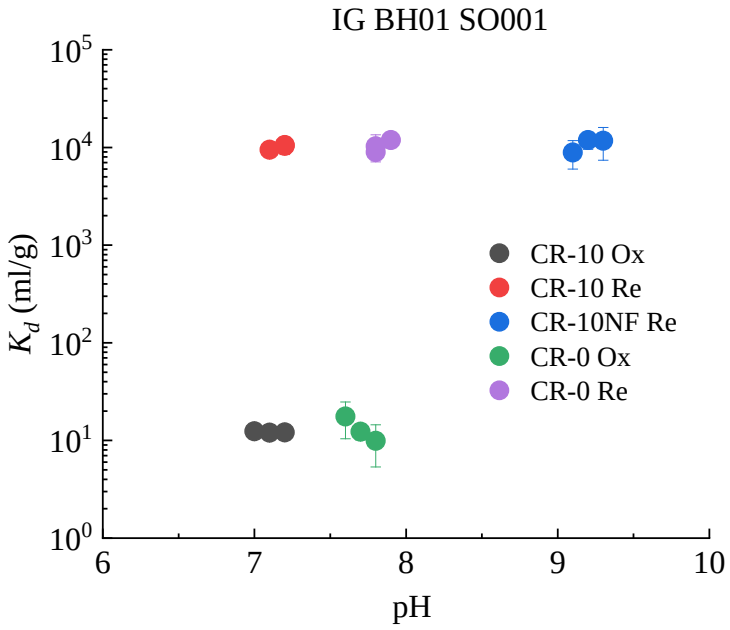


Figure 3-12: K_d values of Tc on IG_BH01_SO001 (biotite granodiorite tonalite) in CR-10, CR-10NF and CR-0 experimental solutions under oxidizing and reducing conditions

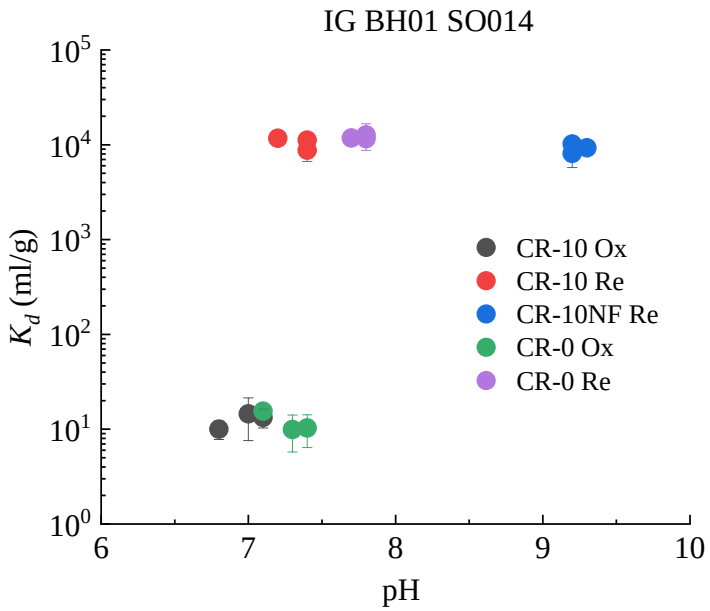


Figure 3-13: K_d values of Tc on IG_BH01_SO014 (biotite granodiorite tonalite) in CR-10, CR-10NF and CR-0 experimental solutions under oxidizing and reducing conditions

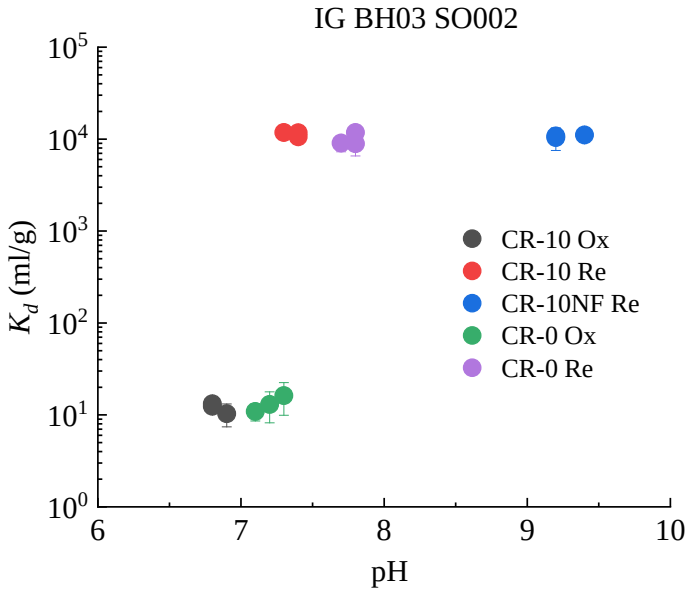


Figure 3-14: K_d values of Tc on IG_BH03_SO002 (biotite granodiorite tonalite) in CR-10, CR-10NF and CR-0 experimental solutions under oxidizing and reducing conditions

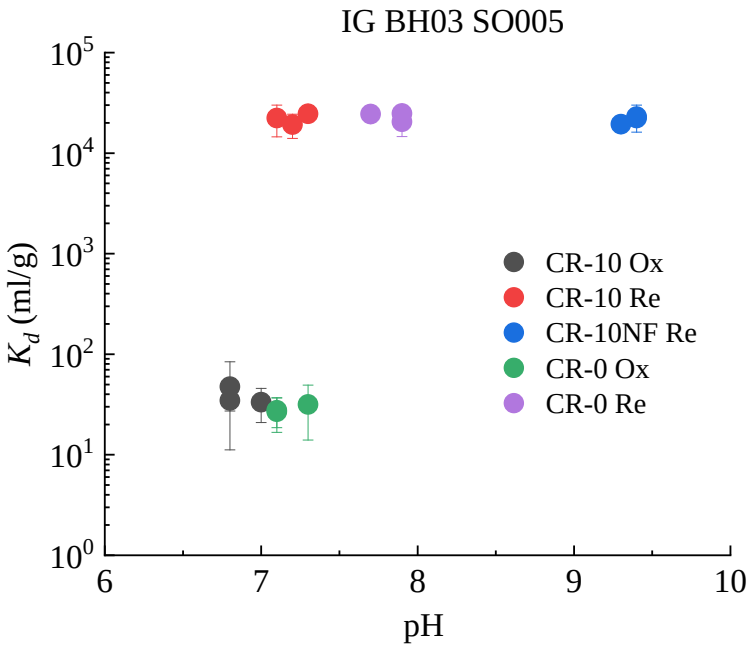


Figure 3-15: K_d values of Tc on IG_BH03_SO005 (amphibolite) in CR-10, CR-10NF and CR-0 experimental solutions under oxidizing and reducing conditions

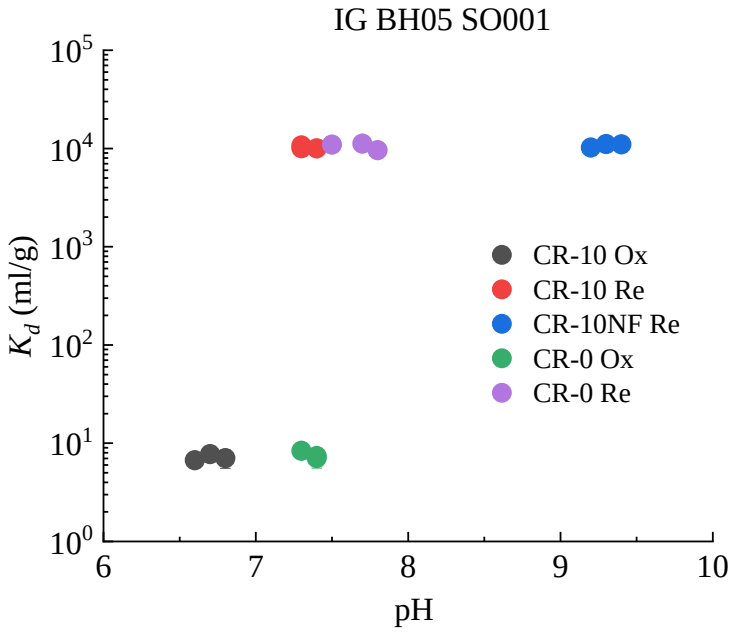


Figure 3-16: K_d values of Tc on IG_BH05_SO001 (diabase dyke) in CR-10, CR-10NF and CR-0 experimental solutions under oxidizing and reducing conditions

All K_d values of Tc(IV) and Tc(VII) are summarized in Figure 3-17 and Figure 3-18. The K_d values of Tc(IV) measured on 3 biotite granodiorite tonalite core samples (IG_BH01_SO001, IG_BH01_SO014 and IG_BH03_SO002) are very similar to each other. The K_d values of Tc(VII) measured on 3 biotite granodiorite tonalite core samples are also very similar to each other. The K_d values of Tc(IV) and Tc(VII) measured on the amphibolite core sample (IG_BH03_SO005) are nearly twice as large as their K_d values measured on 3 biotite granodiorite tonalite core samples. The K_d values of Tc(VII) measured on the diabase dyke core sample (IG_BH05_SO001) are about one half of the K_d values of Tc(VII) measured on the biotite granodiorite tonalite core samples, but the K_d values of Tc(IV) measured on the diabase dyke core sample (IG_BH05_SO001) are identical to those measured on the biotite granodiorite tonalite core samples. This is likely because of the higher biotite and chlorite contents in amphibolite than in biotite granodiorite tonalite and the diabase dyke. Overall, the effect of the oxidation states on the sorption of Tc is significant (K_d of Tc(IV) is about 10^3 times larger than that of Tc(VII) for all three rock types being tested). The effect of solution chemistry on the sorption of Tc(IV) and Tc(VII) is negligible, but an effect of mineral compositions of the biotite granodiorite tonalite, amphibolite, and diabase dyke rock samples has been observed for Tc(VII) and Tc(IV) (note that Tc(IV) sorption on biotite granodiorite tonalite and diabase dyke rock samples is similar). The measured data are summarized in the Appendix (Tables A-26 to A-30).

The K_d values of Tc on granite compiled in the JAEA sorption database are shown in the Appendix (Figures A-3 and A-4). The K_d values obtained in this work are consistent with those compiled in the JAEA database.

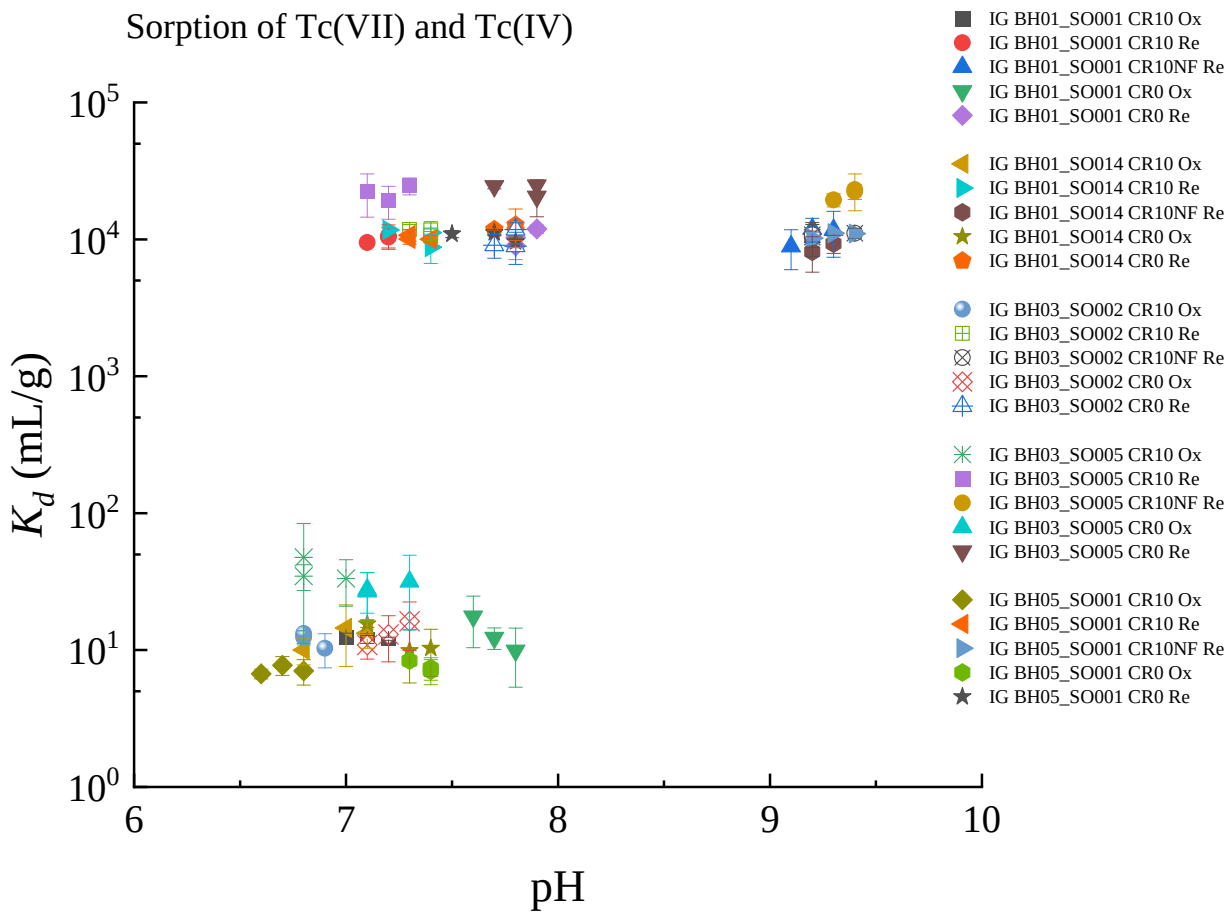


Figure 3-17: K_d values of Tc on IG_BH01_SO001, IG_BH01_SO014, IG_BH03_SO002 (biotite granodiorite tonalite), IG_BH03_SO005 (amphibolite) and IG_BH05_SO001 (diabase dyke) in CR-10, CR-10NF and CR-0 under oxidizing and reducing conditions

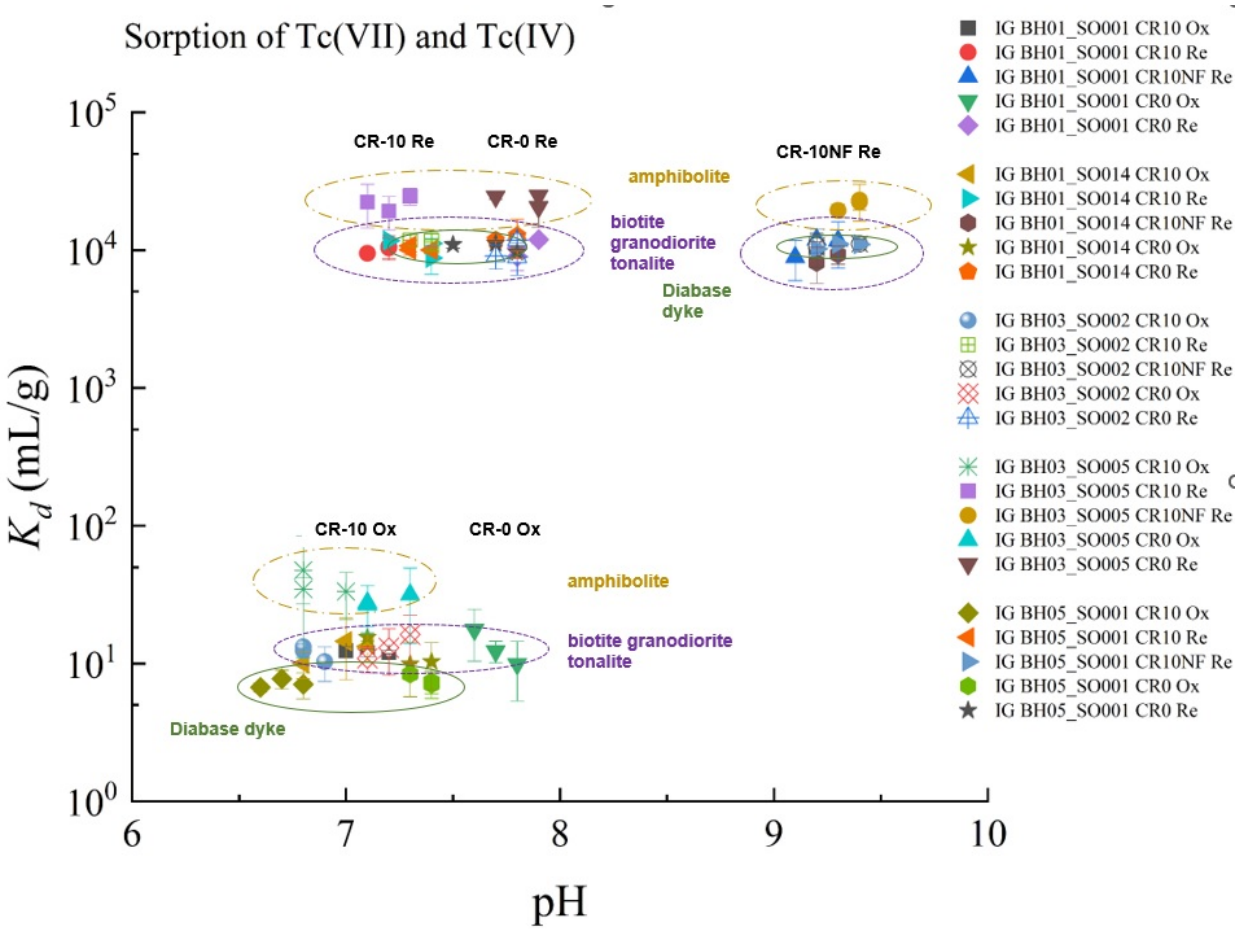


Figure 3-18: Dependence of Tc K_d values on rock types (biotite granodiorite tonalite, amphibolite and diabase dyke) in CR-10, CR-10NF and CR-0 under oxidizing and reducing conditions

3.4 NEPTUNIUM SORPRTION

3.4.1 Sorption Kinetics

The sorption kinetics of Np on IG_BH01_SO001 (biotite granodiorite tonalite) and IG_BH05_SO001 (diabase dyke) are shown in Figure 3-19 and Figure 3-20, respectively. The solid/liquid ratio was set to 1 g/10 mL for Np(V) sorption under oxidizing conditions and 0.01 g/10 mL for Np(IV) sorption under reducing conditions.

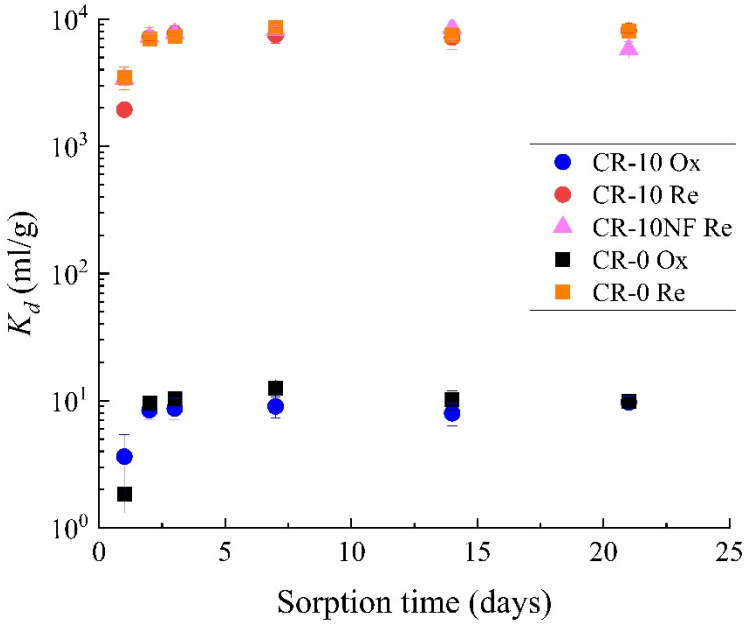


Figure 3-19: Sorption kinetics of Np on IG_BH01_SO001 (biotite granodiorite tonalite) in CR-10, CR-10NF and CR-0 under oxidizing and reducing conditions

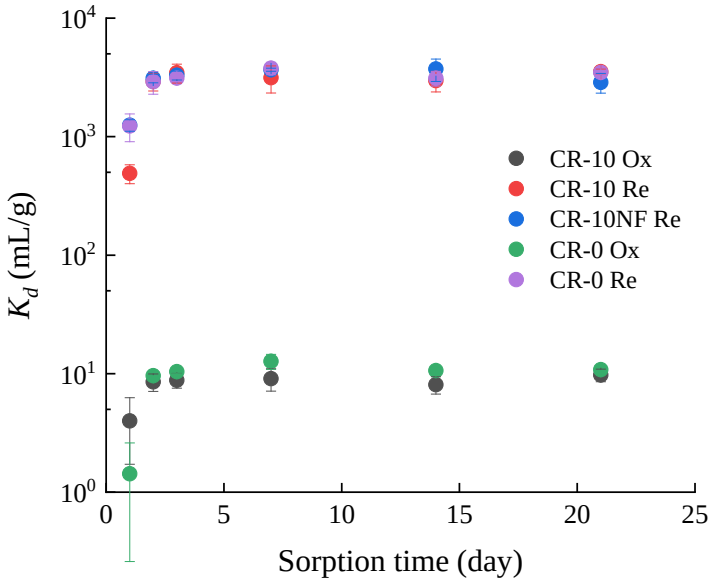


Figure 3-20: Sorption kinetics of Np on IG_BH05_SO001 (diabase dyke) in CR-10, CR-10NF and CR-0 under oxidizing and reducing conditions

The sorption of Np reached equilibrium within 1 week for both IG_BH01_SO001 (biotite granodiorite tonalite) and IG_BH05_SO001 (diabase dyke). Hence, 2 weeks was set for the sorption reaction period for the Np(IV) and Np(V) sorption batch tests. Details of sorption kinetics of Np are summarized in the Appendix (Tables A-31 to A-40).

3.4.2 K_d Value Measurement

The measured Np K_d values are summarized in Figures 3-21 to 3-25.

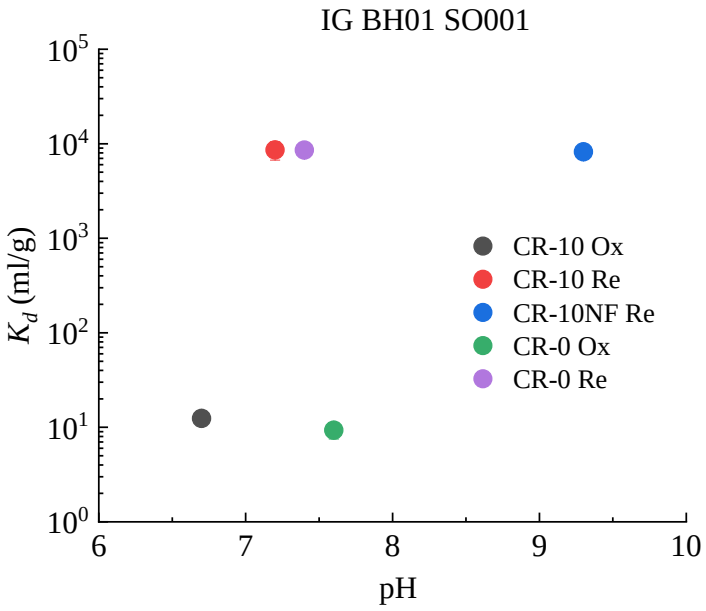


Figure 3-21: K_d values of Np on IG_BH01_SO001 (biotite granodiorite tonalite) in CR-10, CR-10NF and CR-0 under oxidizing and reducing conditions

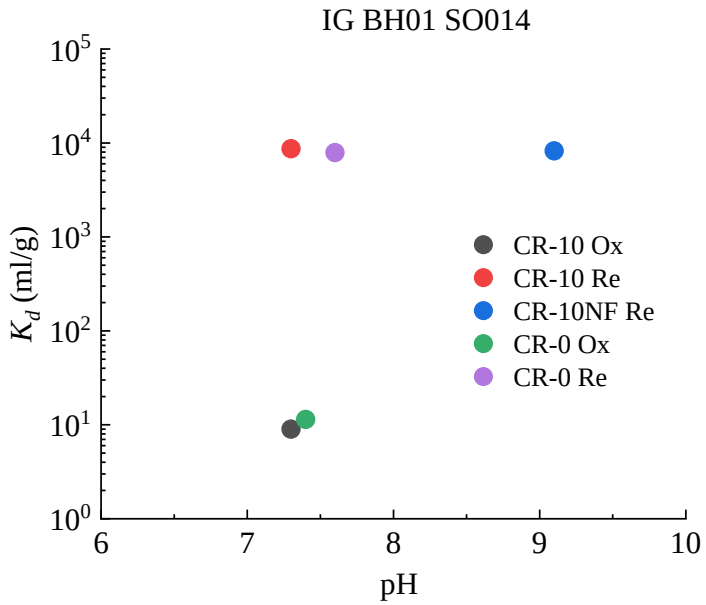


Figure 3-22: K_d values of Np on IG_BH01_SO014 (biotite granodiorite tonalite) in CR-10, CR-10NF and CR-0 under oxidizing and reducing conditions

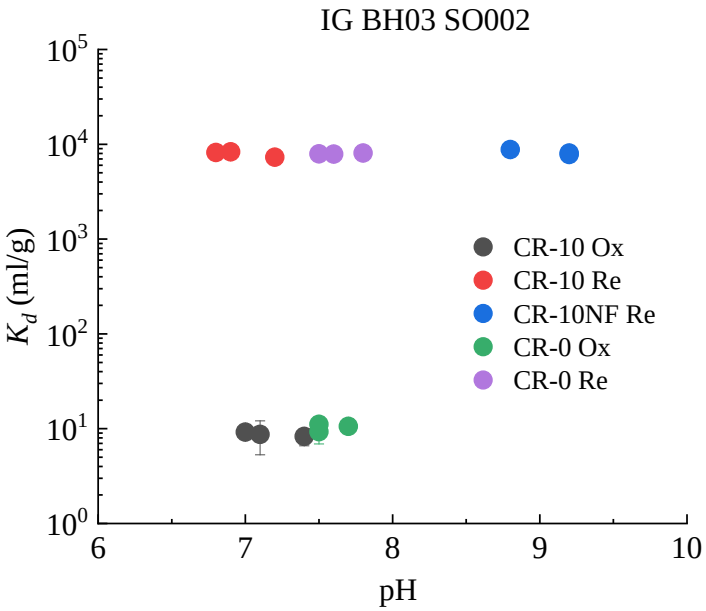


Figure 3-23: K_d values of Np on IG_BH03_SO002 (biotite granodiorite tonalite) in CR-10, CR-10NF and CR-0 under oxidizing and reducing conditions

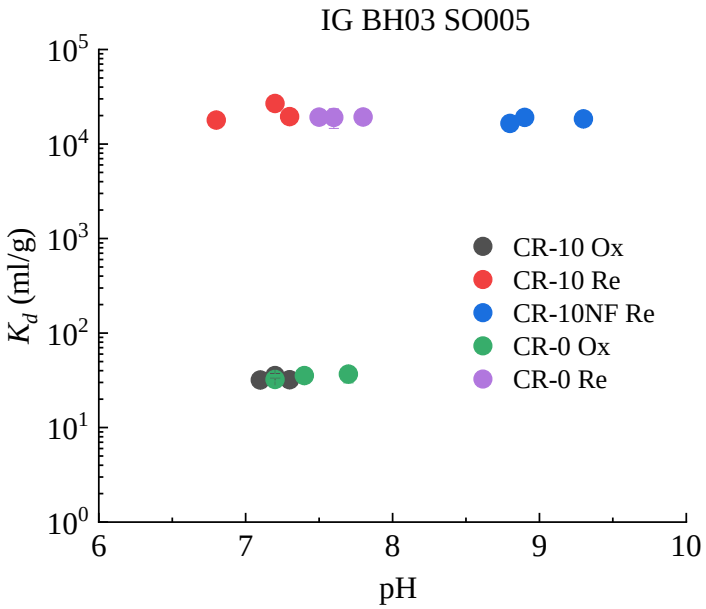


Figure 3-24: K_d values of Np on IG_BH03_SO005 (amphibolite) in CR-10, CR-10NF and CR-0 under oxidizing and reducing conditions

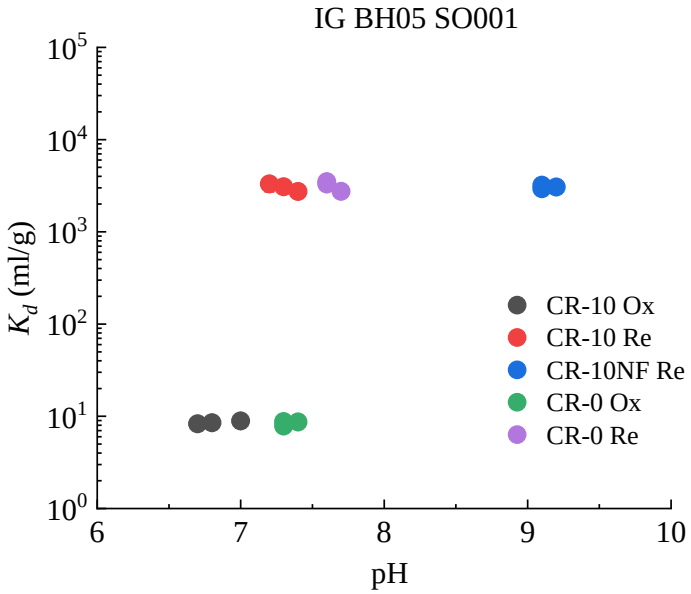


Figure 3-25: K_d values of Np on IG_BH05_SO001 (diabase dyke) in CR-10, CR-10NF and CR-0 under oxidizing and reducing conditions

All K_d values of Np(IV) and Np(V) are summarized in Figure 3-26 and Figure 3-27. The K_d values of Np(IV) measured on 3 biotite granodiorite tonalite core samples (IG_BH01_SO001, IG_BH01_SO014, IG_BH03_SO002) are very similar to each other. The K_d values of Np(V) measured on 3 biotite granodiorite tonalite core samples are also very similar to each other. The K_d values of Np(IV) and Np(V) measured on the amphibolite core sample (IG_BH03_SO005) are nearly twice as large as their K_d values measured on the biotite granodiorite tonalite core samples. The K_d values of Np(IV) measured on the diabase dyke core sample (IG_BH05_SO001) are about one half of the K_d values of Np(IV) measured on the biotite granodiorite tonalite core samples, but the K_d values of Np(V) measured on the diabase dyke core sample (IG_BH05_SO001) are similar to the K_d values of Np(V) measured on the biotite granodiorite tonalite core samples. This is likely because of the higher biotite and chlorite contents in amphibolite than in biotite granodiorite tonalite and the diabase dyke. Overall, the effect of oxidation state on Np sorption is significant (K_d of Np(IV) is about 10^3 times larger than that of Np(V) for the three rock types being tested). The effect of solution chemistry on K_d values of Np(IV) and Np(V) is negligible. However, an effect of mineral compositions of the biotite granodiorite tonalite, amphibolite and diabase dyke rock samples has been observed for Np(IV) and Np(V) (note that Np(V) sorption on biotite granodiorite tonalite and diabase dyke rock samples is similar). The sorption measurement data are summarized in the Appendix (Tables A-41 to A-45).

The K_d values of Np on granite compiled in the JAEA sorption database are shown in the Appendix (Figures A-5 and A-6). The Np K_d values obtained in this work are consistent with those compiled in the JAEA sorption database.

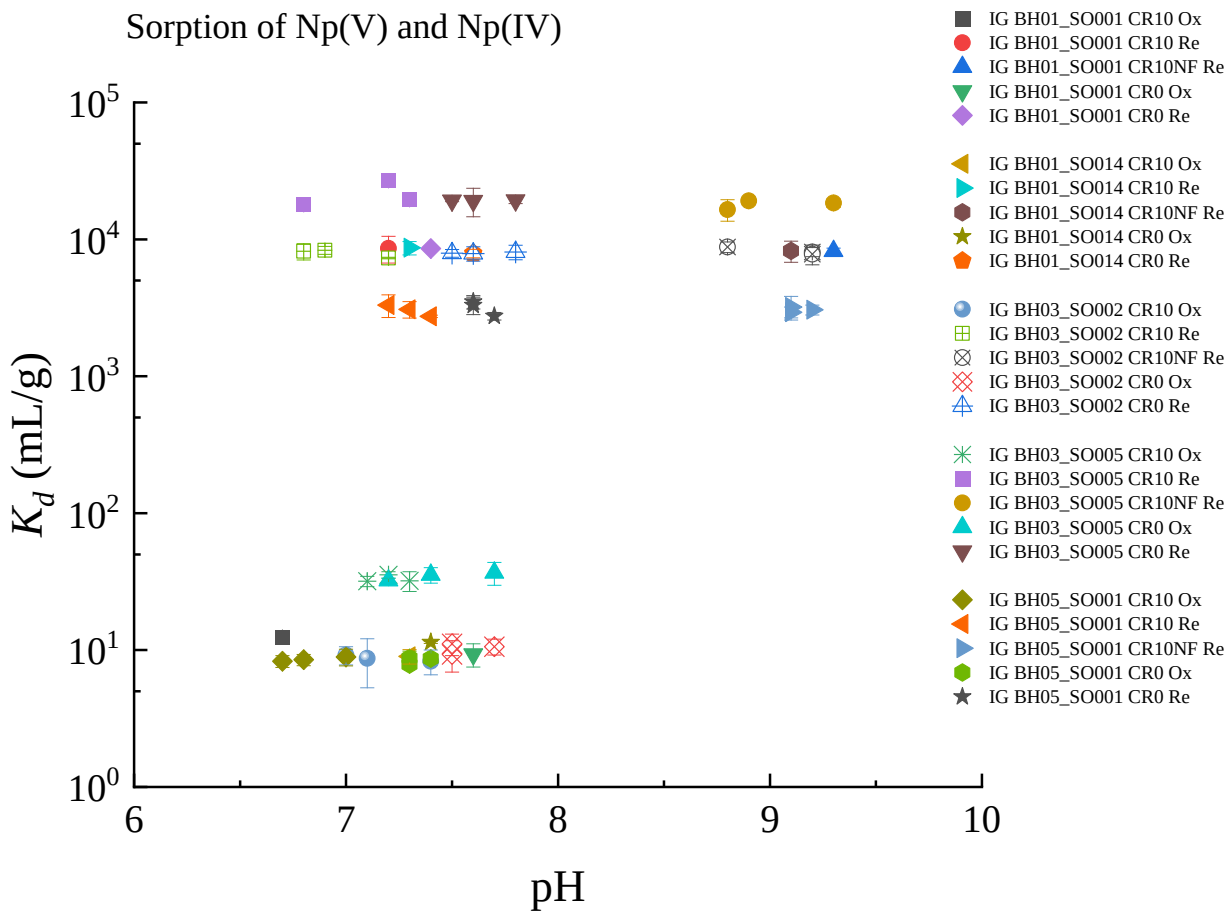


Figure 3-26: Np K_d values measured on IG_BH01_SO001, IG_BH01_SO014, IG_BH03_SO002 (biotite granodiorite tonalite), IG_BH03_SO005 (amphibolite) and IG_BH05_SO001 (diabase dyke) in CR-10, CR-10NF and CR-0 under oxidizing and reducing conditions

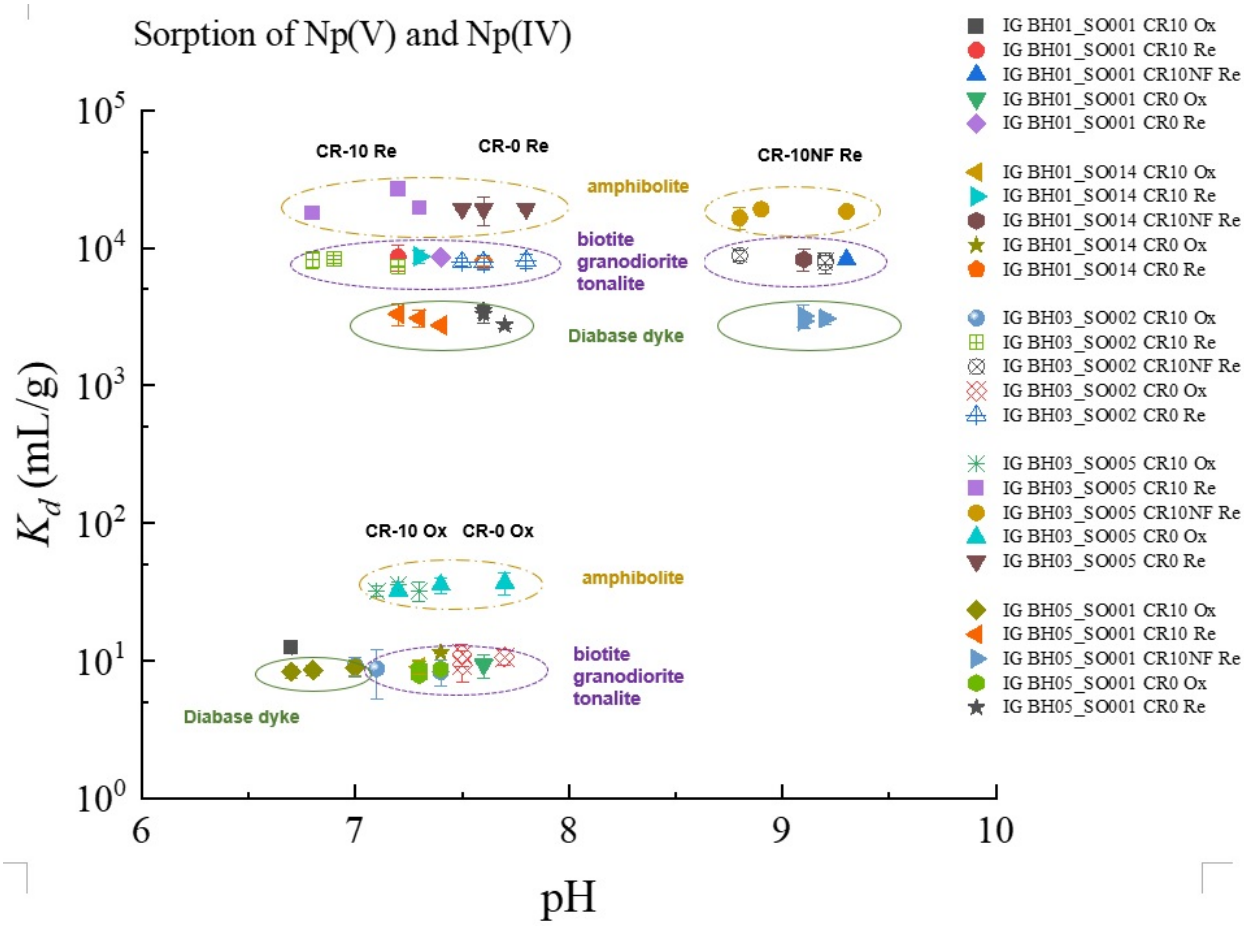


Figure 3-27: Dependence of Np K_d values on rock types (biotite granodiorite tonalite, amphibolite and diabase dyke) and redox conditions (Ox: oxidizing conditions, Re: reducing conditions)

3.5 URANIUM SORPRTION

3.5.1 Sorption Kinetics

The sorption kinetics of U on IG_BH01_SO014 (biotite granodiorite tonalite), IG_BH03_SO005 (amphibolite) and IG_BH05_SO001 (diabase dyke) are shown in Figures 3-28, 3-29, and 3-30, respectively. The solid/liquid ratio was set to 1 g/10 mL for U(VI) sorption under oxidizing conditions and 0.01 g/10 mL for U(IV) sorption under reducing conditions.

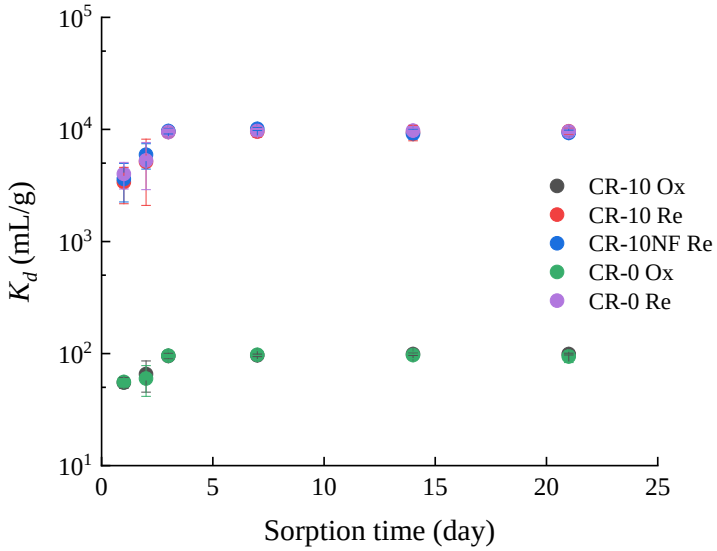


Figure 3-28: Sorption kinetics of U on IG_BH01_SO014 (biotite granodiorite tonalite) in CR-10, CR-10NF and CR-0 under oxidizing and reducing conditions

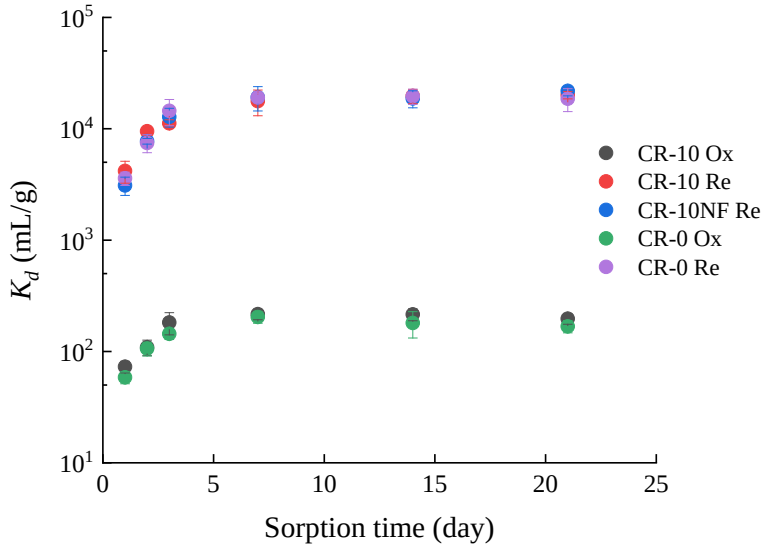


Figure 3-29: Sorption kinetics of U on IG_BH03_SO005 (amphibolite) in CR-10, CR-10NF and CR-0 under oxidizing and reducing conditions

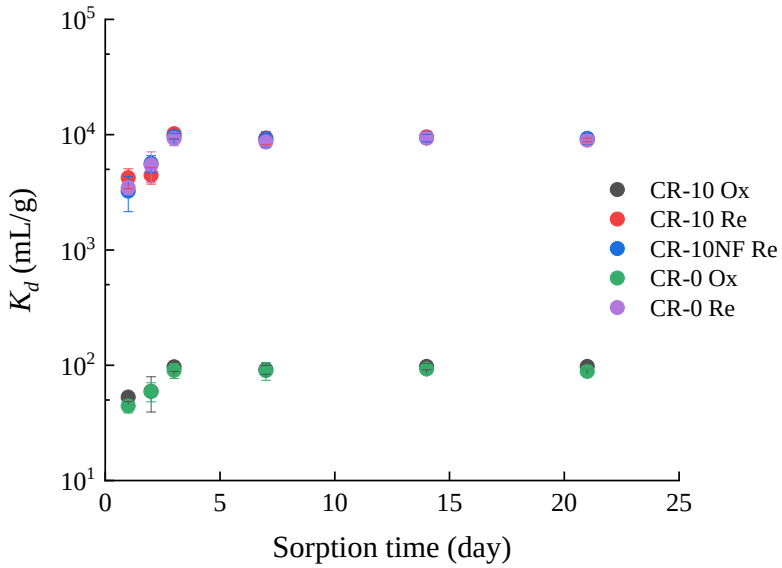


Figure 3-30: Sorption kinetics of U on IG_BH05_SO001 (diabase dyke) in CR-10, CR-10NF and CR-0 under oxidizing and reducing conditions

The sorption of U reached equilibrium in 1 week for all the sorption kinetics tests. Hence, the sorption reaction period of U(IV) and U(VI) sorption batch tests was set for 2 weeks. Details of sorption kinetics of U are summarized in the Appendix (Tables A-46 to A-60).

3.5.2 K_d Value Measurement

The U K_d values measured are summarized in Figures 3-31 to 3-35.

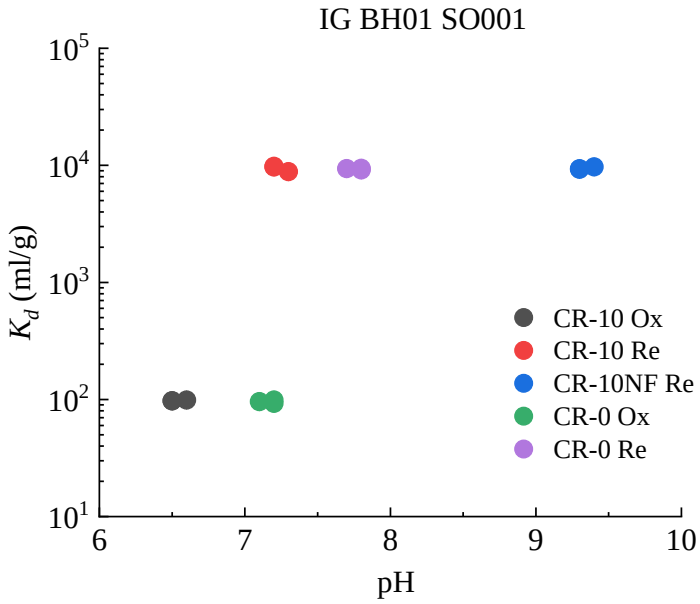


Figure 3-31: K_d values of U on IG_BH01_SO001 (biotite granodiorite tonalite) in CR-10, CR-10NF and CR-0 under oxidizing and reducing conditions

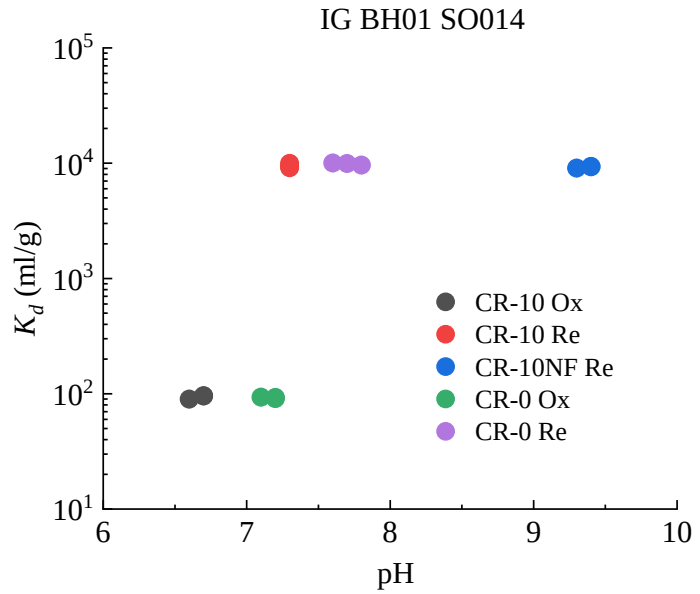


Figure 3-32: K_d values of U on IG_BH01_SO014 (biotite granodiorite tonalite) in CR-10, CR-10NF and CR-0 under oxidizing and reducing conditions

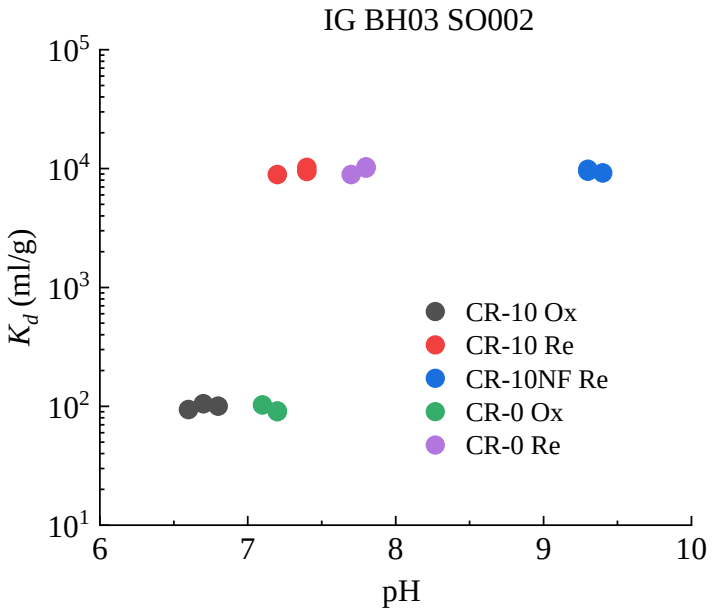


Figure 3-33: K_d values of U on IG_BH03_SO002 (biotite granodiorite tonalite) in CR-10, CR-10NF and CR-0 under oxidizing and reducing conditions

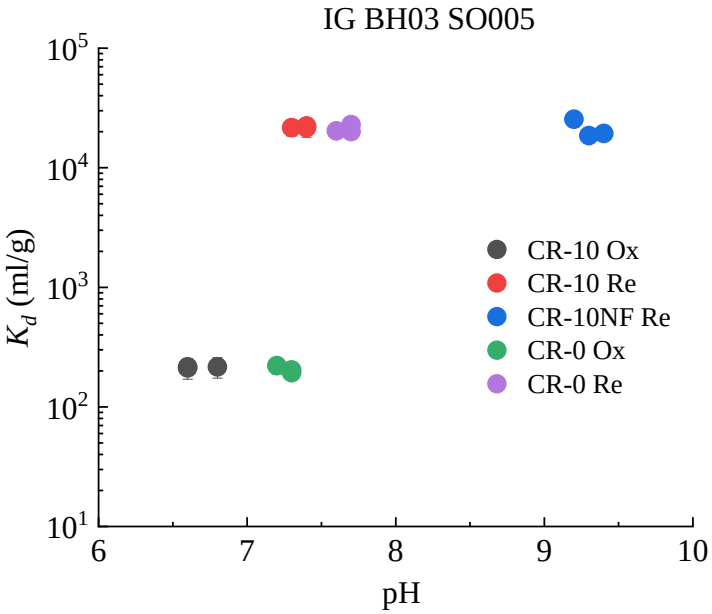


Figure 3-34: K_d values of U on IG_BH03_SO005 (amphibolite) in CR-10, CR-10NF and CR-0 under oxidizing and reducing conditions

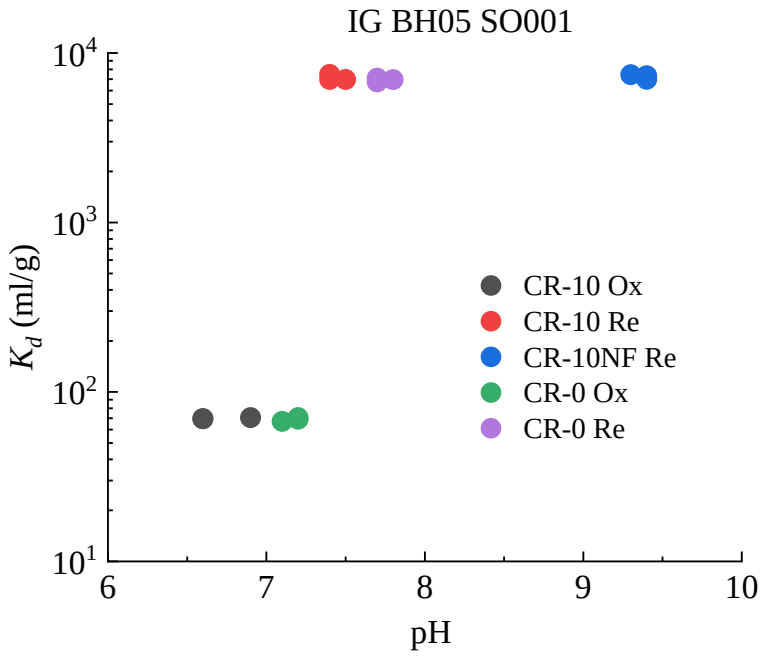


Figure 3-35: K_d values of U on IG_BH05_SO001 (diabase dyke) in CR-10, CR-10NF and CR-0 under oxidizing and reducing conditions

All K_d values of U(IV) and U(VI) for 5 core samples are summarized in Figure 3-36 and Figure 3-37. The K_d values of U(IV) on 3 biotite granodiorite tonalite core samples (IG_BH01_SO001, IG_BH01_SO014, IG_BH03_SO002) are very similar to each other. The K_d values of U(VI) on 3 biotite granodiorite tonalite core samples are also very similar to each other. The K_d values of U(IV) and U(VI) on the amphibolite core sample (IG_BH03_SO005) are nearly twice as large as their K_d values measured on the biotite granodiorite tonalite core samples. The K_d values of U(IV) and U(VI) measured on the diabase dyke core sample (IG_BH05_SO001) are almost the same as their K_d values measured on the biotite granodiorite tonalite core samples. This is likely because of the higher biotite and chlorite contents in amphibolite than in biotite granodiorite tonalite and the diabase dyke. Overall, the effect of oxidation state on U sorption is significant (K_d of U(IV) is about 100 times larger than that of U(VI) for the 3 rock types). The effect of solution chemistry on K_d values of U(IV) and U(VI) is negligible. An effect due to the mineral compositions of biotite granodiorite tonalite/diabase dyke and amphibolite has been observed for U(IV) and U(VI). The sorption measurement data are summarized in Appendix (Tables A-61 to A-65).

The K_d values of U on granite compiled in the JAEA sorption database are shown in the Appendix (Figures A-7 and A-8). The K_d values obtained in this work are consistent with those compiled in the JAEA sorption database.

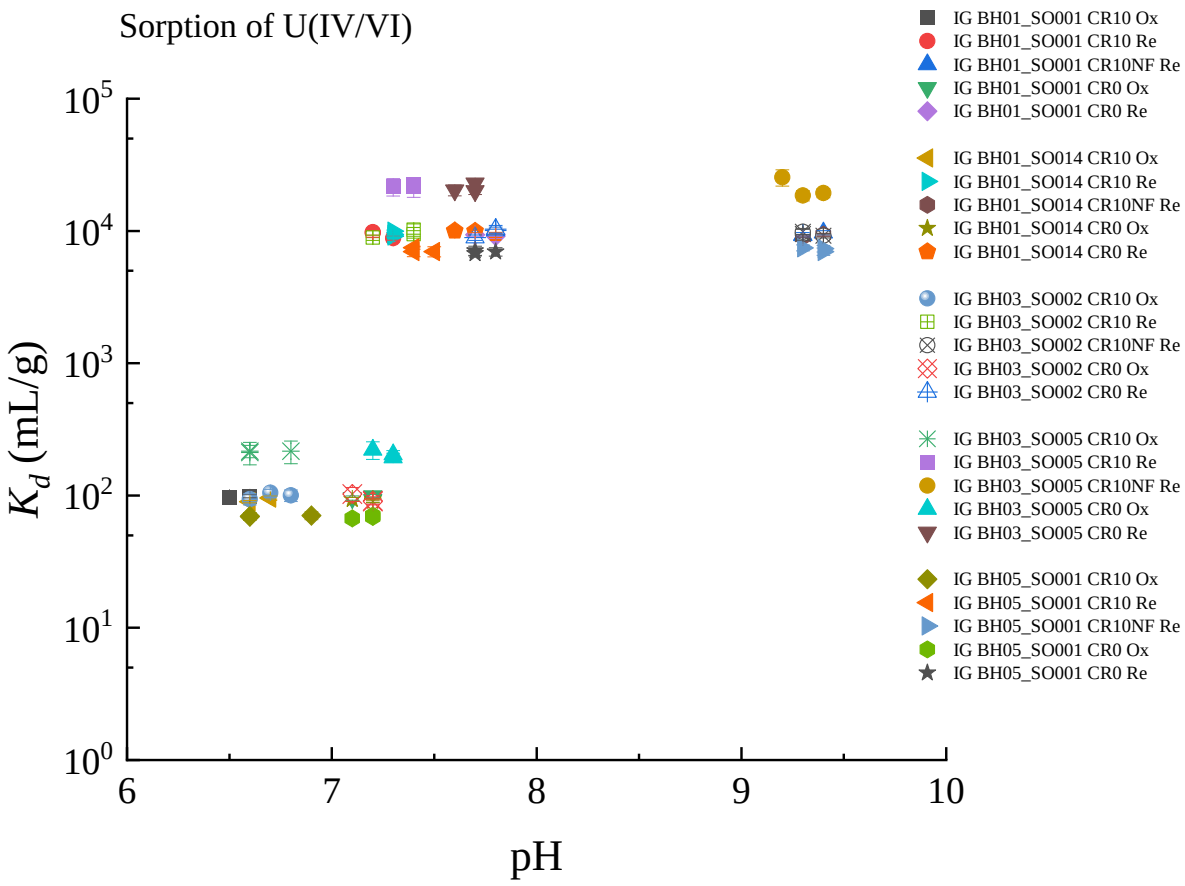


Figure 3-36: U K_d values measured on IG_BH01_SO001, IG_BH01_SO014, IG_BH03_SO002 (biotite granodiorite tonalite), IG_BH03_SO005 (amphibolite) and IG_BH05_SO001 (diabase dyke) in CR-10, CR-10NF and CR-0 under oxidizing and reducing conditions

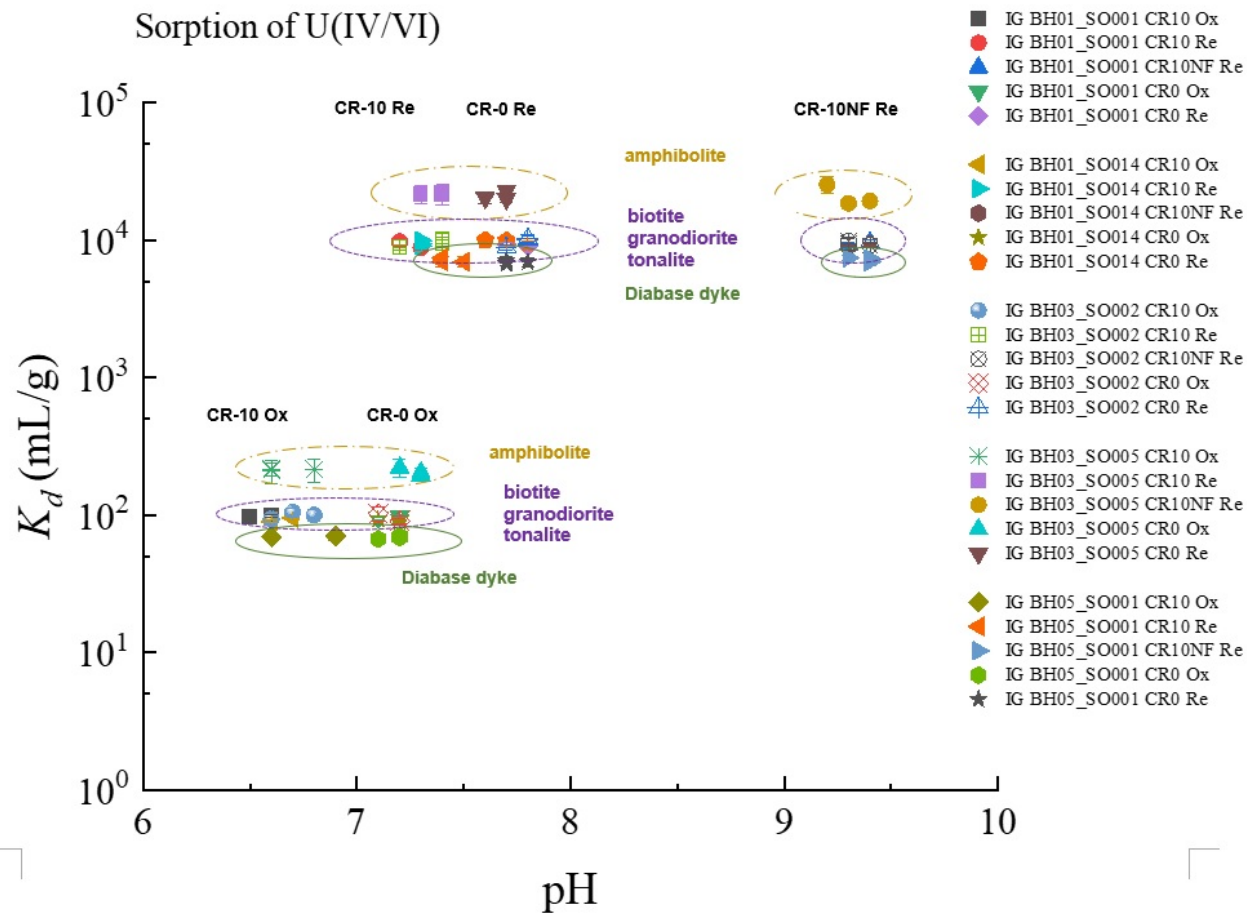


Figure 3-37: Dependence of U K_d values on rock types (biotite granodiorite tonalite, amphibolite and diabase dyke) and redox conditions (Ox: oxidizing conditions, Re: reducing conditions)

3.6 EUROPIUM SORPRTION

3.6.1 Sorption Kinetics

The sorption kinetics of Eu on IG_BH01_SO001 (biotite granodiorite tonalite) and IG_BH05_SO001 (diabase dyke) are shown in Figure 3-38 and Figure 3-39, respectively. The solid/liquid ratio was set to 0.01 g/10 mL for all experimental conditions.

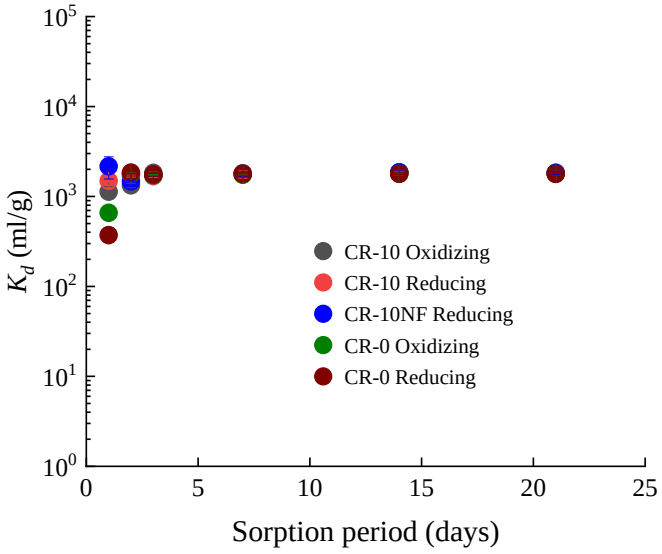


Figure 3-38: Sorption kinetics of Eu on IG_BH01_SO001 (biotite granodiorite tonalite) in CR-10, CR-10NF and CR-0 under oxidizing and reducing conditions

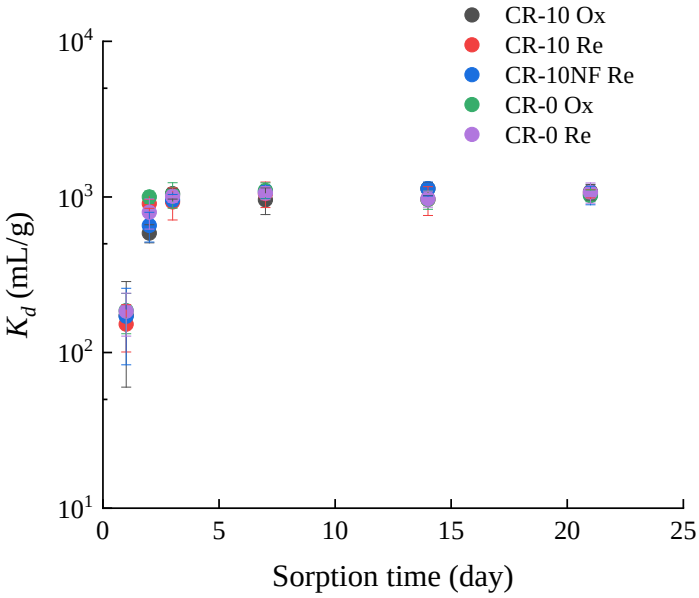


Figure 3-39: Sorption kinetics of Eu on IG_BH05_SO001 (diabase dyke) in CR-10, CR-10NF and CR-0 under oxidizing and reducing conditions

The sorption of Eu reached equilibrium within 3 days and 1 week on IG_BH01_SO001 and IG_BH05_SO001, respectively. Hence, 1 week was set for the reaction period for Eu sorption batch tests on IG_BH01_SO001, IG_BH01_SO014, IG_BH03_SO002 and IG_BH03_ SO005. 2 weeks were set for the reaction period for Eu sorption batch tests on IG_BH05_SO001. Details of sorption kinetics of Eu(III) are summarized in the Appendix (Tables A-66 to A-75).

3.6.2 K_d Value Measurement

The measured Eu K_d values for 5 core samples are summarized in Figures 3-40 to 3-44.

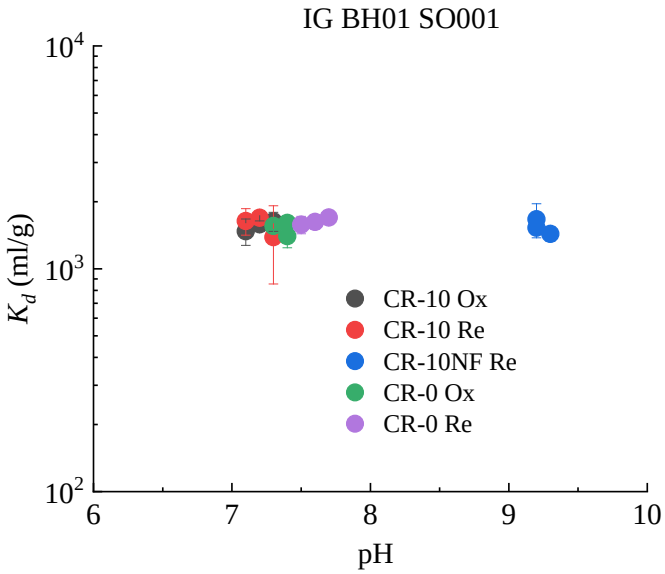


Figure 3-40: K_d values of Eu on IG_BH01_SO001 (biotite granodiorite tonalite) in CR-10, CR-10NF and CR-0 under oxidizing and reducing conditions

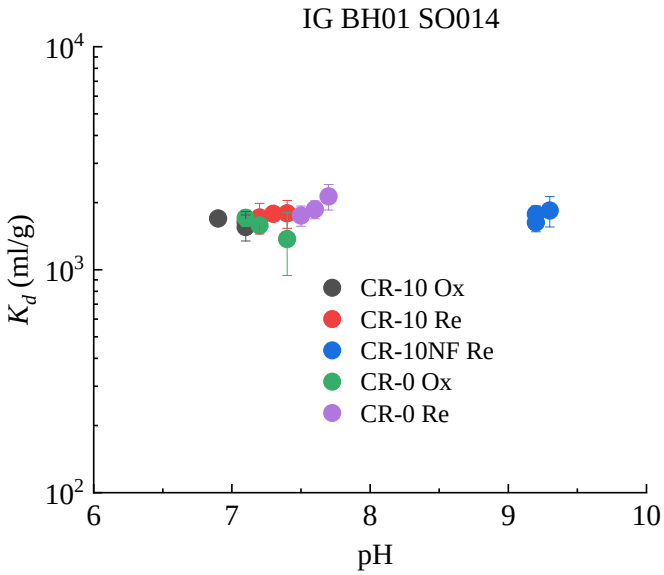


Figure 3-41: K_d values of Eu on IG_BH01_SO014 (biotite granodiorite tonalite) in CR-10, CR-10NF and CR-0 under oxidizing and reducing conditions

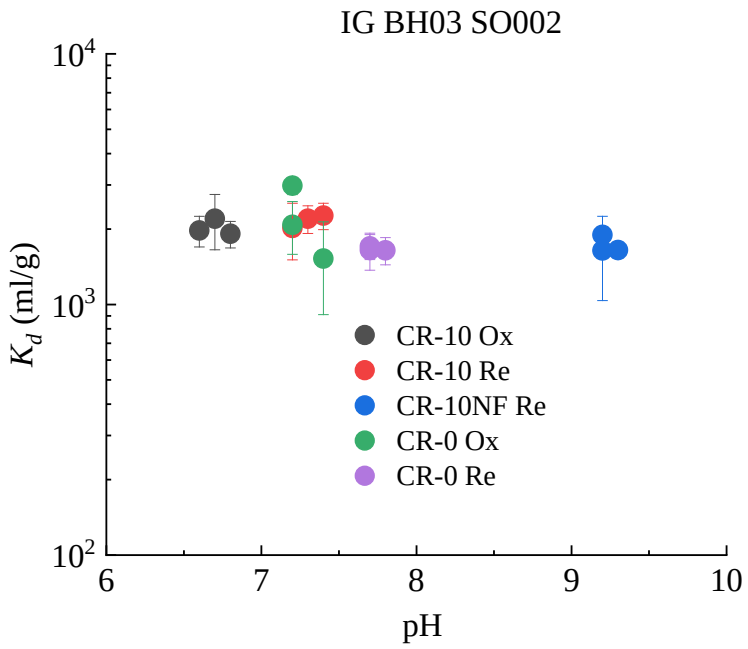


Figure 3-42: K_d values of Eu on IG_BH03_SO002 (biotite granodiorite tonalite) in CR-10, CR-10NF and CR-0 under oxidizing and reducing conditions

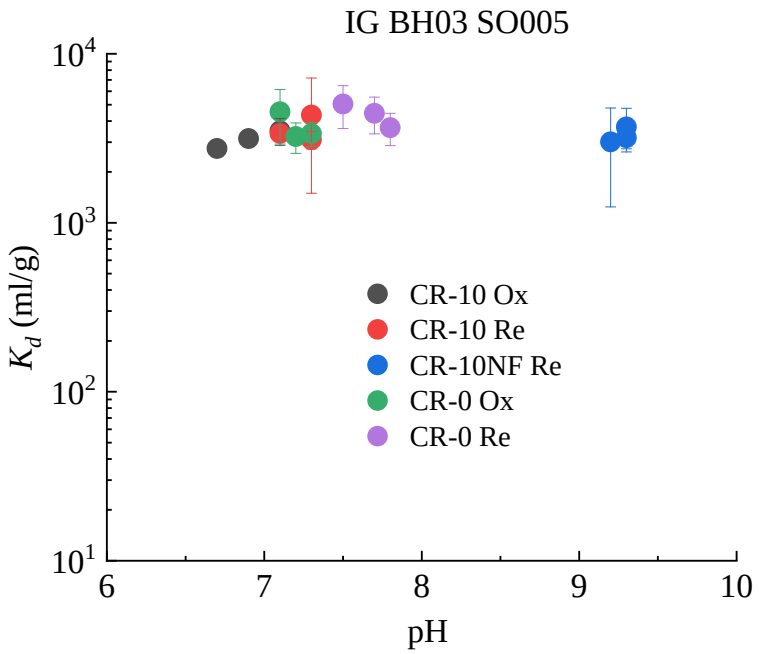


Figure 3-43: K_d values of Eu on IG_BH03_SO005 (amphibolite) in CR-10, CR-10NF and CR-0 under oxidizing and reducing conditions

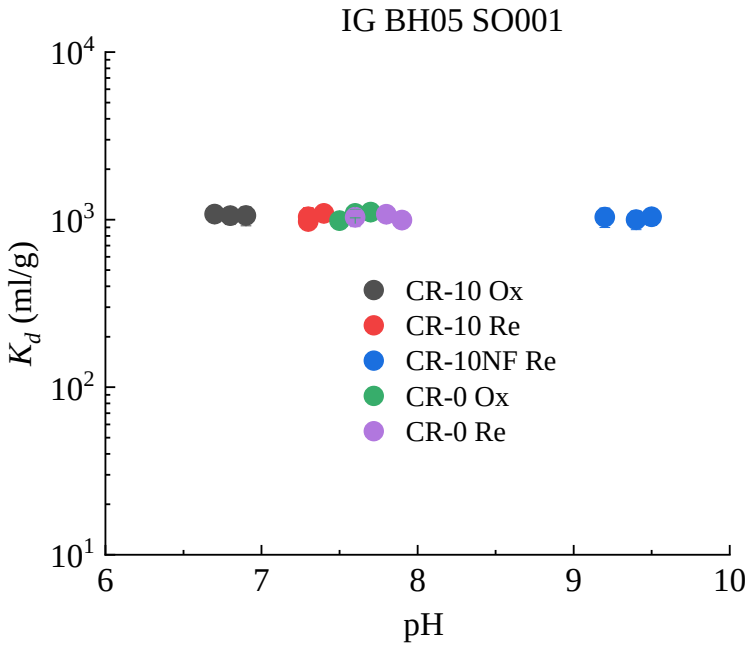


Figure 3-44: K_d values of Eu on IG_BH05_SO001 (diabase dyke) in CR-10, CR-10NF and CR-0 under oxidizing and reducing conditions

All K_d values of Eu are summarized in Figure 3-45 and Figure 3-46. The K_d values of Eu(III) on 3 biotite granodiorite tonalite core samples (IG_BH01_SO001, IG_BH01_SO014, IG_BH03_SO002) are very similar to each other. The K_d values of Eu(III) measured on the amphibolite core sample (IG_BH03_SO005) are nearly twice as large as those measured on the 3 biotite granodiorite tonalite core samples. The K_d values of Eu(III) measured on the diabase dyke core sample (IG_BH05_SO001) are about one half of the K_d values measured on the 3 biotite granodiorite tonalite core samples. This is likely because of the higher biotite and chlorite contents in amphibolite than in biotite granodiorite tonalite and the diabase dyke. Overall, the effect of solution chemistry on K_d of Eu(III) is negligible, but the effect of mineral compositions of biotite granodiorite tonalite, amphibolite, and diabase dyke has been observed. The sorption measurement data are summarized in the Appendix (Tables A-76 to A-80).

The K_d values of Eu on granite compiled in the JAEA sorption database are shown in the Appendix (Figures A-9 and A-10). The K_d values obtained in this work are consistent with those compiled in the JAEA sorption database.

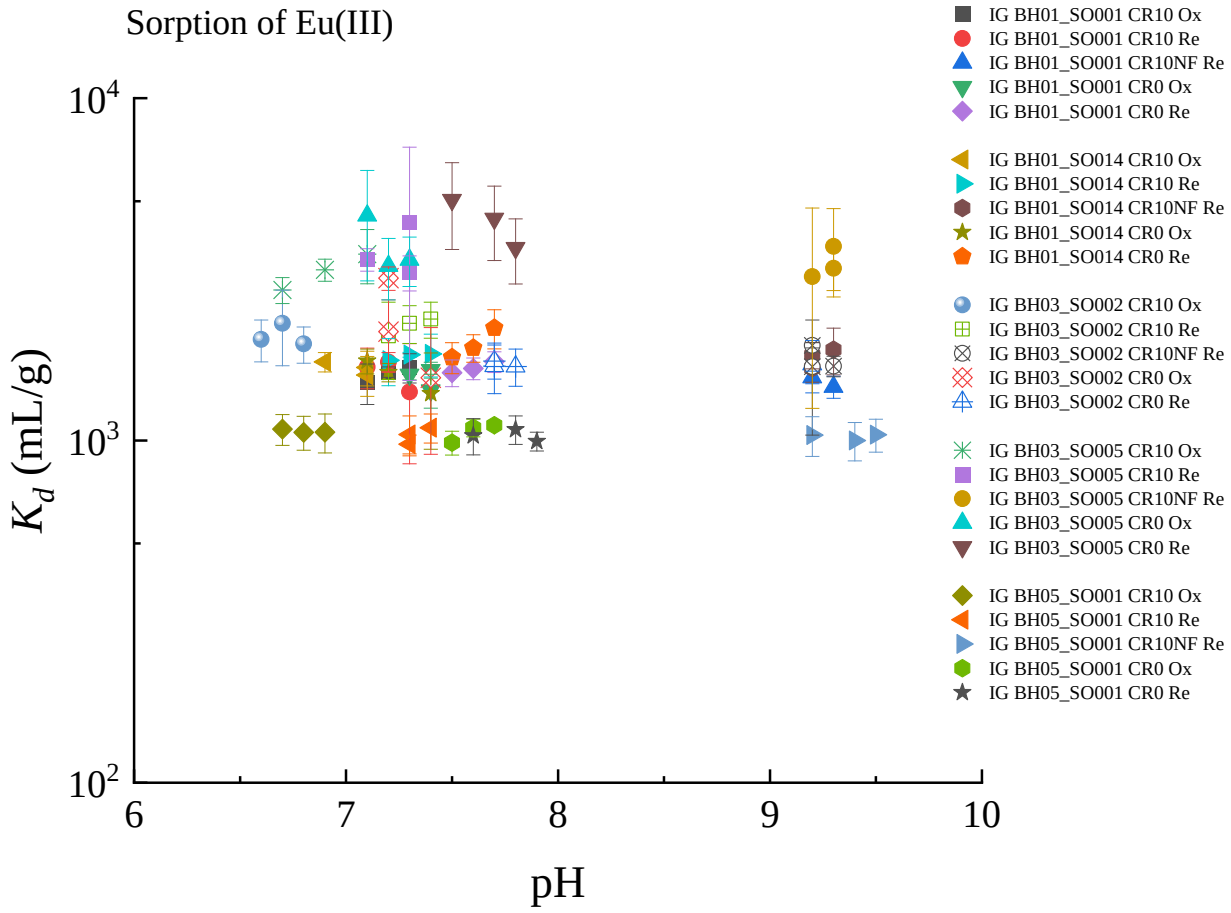


Figure 3-45: Eu K_d values measured on IG_BH01_SO001, IG_BH01_SO014, IG_BH03_SO002 (biotite granodiorite tonalite), IG_BH03_SO005 (amphibolite) and IG_BH05_SO001 (diabase dyke) in CR-10, CR-10NF and CR-0 under oxidizing and reducing conditions

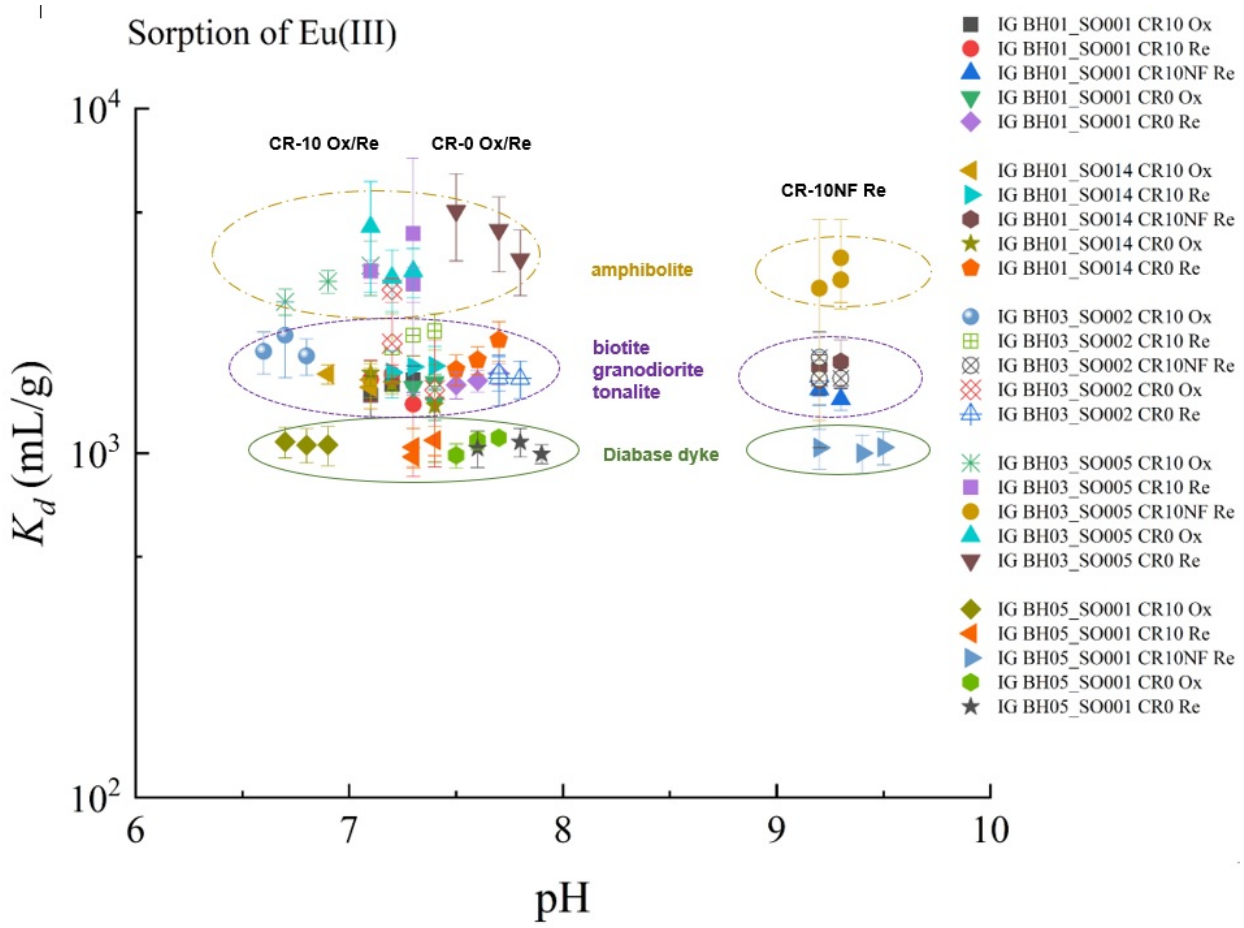


Figure 3-46: Dependence of Eu K_d values on rock types (biotite granodiorite tonalite, amphibolite and diabase dyke)

4. CONCLUSIONS

The sorption kinetics were measured for Se, Tc, Np and Eu on core samples IG_BH01 SO001 (biotite granodiorite tonalite) and IG_BH05_SO001 (diabase dyke) in the reference groundwater CR-10 (under oxidizing and reducing conditions), CR-10NF (under reducing condition) and CR-0 (under oxidizing and reducing conditions), and for U on core samples IG_BH01_SO014 (biotite granodiorite tonalite), IG_BH03_SO005 (amphibolite) and IG_BH05_SO001 (diabase dyke) in the reference groundwater CR-10 (under oxidizing and reducing conditions), CR-10NF (under reducing conditions) and CR-0 (under oxidizing and reducing conditions).

It was found that the sorption equilibrium was achieved in (1) 1 week for Se and Np on IG_BH01_SO001 and IG_BH05_SO001; (2) 1 week for U on IG_BH01_SO014, IG_BH03_SO005 and IG_BH05_SO005; and (3) 3 days for Tc and Eu on IG_BH01_SO001, and 1 week for Tc and Eu on IG_BH03_SO005. Therefore, the sorption reaction periods for K_d batch measurements were set as (1) 2 weeks for Se(IV/VI), Se(-II), Np(V), Np(IV), U(VI) and U(IV) on all five core samples, and Tc(IV), Tc(VII) and Eu on IG_BH05_SO001; and (2) 1 week for Tc(VII), Tc(IV) and Eu on IG_BH01_SO001, IG_BH01_SO014, IG_BH03_SO002 and IG_BH03_SO005 in this study.

The K_d values of Se, Tc, Np, U and Eu on five core samples IG_BH01_SO001, IG_BH01_SO014 and IG_BH03_SO002 (biotite granodiorite tonalite), IG_BH03_SO005 (amphibolite) and IG_BH05_SO001 (diabase dyke) were measured in CR-10 (under oxidizing and reducing conditions), CR-10NF (under reducing conditions) and CR-0 (under oxidizing and reducing conditions).

The measured K_d values of Se, Tc, Np, U and Eu are summarized in Tables 4-1 to 4-5.

The respective K_d values of Se(-II) and Se(IV/VI) on 3 biotite granodiorite tonalite core samples (IG_BH01_SO001, IG_BH01_SO014 and IG_BH03_SO002) are very similar to each other. The K_d values of Se(-II) and Se(IV/VI) measured on the amphibolite core sample (IG_BH03_SO005) are nearly twice as large as their K_d values measured on the biotite granodiorite tonalite core samples. The K_d values of Se(-II) and Se(IV/VI) measured on the diabase dyke core sample (IG_BH05_SO001) are about one half of their K_d values measured on the biotite granodiorite tonalite core samples (IG_BH01_SO001, IG_BH01_SO014 and IG_BH03_SO002).

The respective K_d values of Tc(IV) and Tc(VII) measured on 3 biotite granodiorite tonalite core samples are very similar to each other. The K_d values of Tc(IV) and Tc(VII) measured on the amphibolite core sample (IG_BH03_SO005) are nearly twice as large as their K_d values measured on biotite granodiorite tonalite core samples. The K_d values of Tc(VII) measured on the diabase dyke core sample (IG_BH05_SO001) are about one half of the K_d values measured on the biotite granodiorite tonalite core samples, but the K_d values of Tc(IV) measured on the diabase dyke core sample (IG_BH05_SO001) were identical to those measured on the biotite granodiorite tonalite core samples.

The respective K_d values of Np(IV) and Np(V) measured on 3 biotite granodiorite tonalite core samples are very similar to each other. The K_d values of Np(IV) and Np(V) measured on the amphibolite core sample (IG_BH03_SO005) are nearly twice as large as their K_d values measured on biotite granodiorite tonalite core samples. The K_d values of Np(IV) measured on the diabase dyke core sample (IG_BH05_SO001) are about one half of the K_d values measured on the biotite granodiorite tonalite core samples, but the K_d values of Np(V) measured on the

diabase dyke core sample (IG_BH05_SO001) were similar to those measured on the biotite granodiorite tonalite core samples.

The respective K_d values of U(IV) and U(VI) measured on 3 biotite granodiorite tonalite core samples are very similar to each other. The K_d values of U(IV) and U(VI) measured on the amphibolite core sample (IG_BH03_SO005) are nearly twice as large as their K_d values measured on the biotite granodiorite tonalite core samples. The K_d values of U(IV) and U(VI) measured on the diabase dyke core sample (IG_BH05_SO001) are almost the same as their K_d values measured on the biotite granodiorite tonalite core samples.

The K_d values of Eu(III) measured on 3 biotite granodiorite tonalite core samples are very similar to each other. The K_d values of Eu(III) measured on the amphibolite core sample (IG_BH03_SO005) are nearly twice as large as those measured on the biotite granodiorite tonalite core samples. The K_d values of Eu(III) measured on the diabase dyke core sample (IG_BH05_SO001) are about one half of the K_d values on the biotite granodiorite tonalite core samples.

Overall, the effect of the oxidation state on sorption is found to be significant for Tc, Np and U; K_d values of Tc(IV) and Np(IV) under reducing conditions are about 10^3 times larger than that of Tc(VII) and Np(V) under oxidizing conditions for the 3 rock types tested. K_d values of U(IV) under reducing conditions are about 10^2 times larger than that of U(VI) under oxidizing conditions for the 3 rock types tested. On the other hand, K_d values of Se(-II) under reducing conditions are larger than that of Se(IV/VI) under oxidizing conditions for the 3 rock types tested, but the difference is small. An effect due to the mineral compositions of biotite granodiorite tonalite, amphibolite and diabase dyke has been observed. In many cases, the K_d values measured on the amphibolite core sample (IG_BH03_SO005) is nearly twice as large as the K_d values measured on the biotite granodiorite tonalite core samples, and the K_d values measured on the diabase dyke core sample (IG_BH05_SO001), and are about one half of the K_d values measured on the biotite granodiorite tonalite core samples. However, the effect of solution salinity on K_d values has not been observed for any of the elements studied (Se, Tc, U, Np, Eu).

All K_d values of Se(IV/VI), Se(-II), Tc(VII), Tc(IV), Np(V), Np(IV), U(VI), U(IV) and Eu(III) measured in this study are consistent with the K_d values compiled in the JAEA Sorption Database.

Table 4-1: Summary of K_d Values of Se(-II) and Se(IV/VI) on 5 Core Samples in CR-10, CR-10NF, and CR-0 under Both Oxidizing and Reducing Conditions

IG_BH01_SO001 (biotite granodiorite tonalite)																			
CR-10 Ox				CR-10 Re				CR-10NF Re				CR-0 Ox				CR-0 Re			
pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error
7.2	320	5.61E+01	1.94E+01	7.3	-200	1.16E+02	1.57E+01	9	-210	1.10E+02	4.40E+00	7.4	300	5.88E+01	2.05E+01	7.3	-210	1.10E+02	3.90E+00
IG_BH01_SO014 (biotite granodiorite tonalite)																			
CR-10 Ox				CR-10 Re				CR-10NF Re				CR-0 Ox				CR-0 Re			
pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error
7.1	310	5.88E+01	1.26E+01	7.2	-210	1.28E+02	1.10E+00	9	-200	1.19E+02	2.30E+01	7.6	310	6.27E+01	1.25E+01	7.5	-200	1.08E+02	1.78E+01
IG_BH03_SO002 (biotite granodiorite tonalite)																			
CR-10 Ox				CR-10 Re				CR-10NF Re				CR-0 Ox				CR-0 Re			
pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error
7.2	300	6.78E+01	3.00E-01	7	-200	1.31E+02	4.89E+01	9.2	-200	1.30E+02	3.91E+01	7.6	310	5.64E+01	8.80E+00	7.5	-190	1.04E+02	1.10E+01
7.1	300	9.07E+01	7.10E+00	6.9	-200	1.30E+02	3.65E+01	9	-190	1.09E+02	4.20E+00	7.7	300	5.10E+01	2.16E+01	7.4	-190	1.24E+02	1.86E+01
6.9	310	5.32E+01	1.09E+01	7.2	-200	1.09E+02	2.20E+00	8.9	-200	1.06E+02	2.00E+00	7.4	290	4.78E+01	2.10E+01	7.7	-200	1.07E+02	6.90E+00
IG_BH03_SO005 (amphibolite)																			
CR-10 Ox				CR-10 Re				CR-10NF Re				CR-0 Ox				CR-0 Re			
pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error
7.3	300	6.44E+01	1.99E+01	6.8	-200	2.35E+02	8.17E+01	9.1	-210	2.45E+02	1.02E+02	7.6	300	9.68E+01	5.69E+01	7.7	-190	3.62E+02	1.48E+02
6.8	310	7.89E+01	2.00E+01	6.9	-190	2.16E+02	7.89E+01	9.4	-200	2.46E+02	1.28E+02	7.4	300	8.00E+01	5.20E+00	7.3	-190	2.02E+02	2.97E+01
7.1	300	6.96E+01	3.00E+00	7.2	-200	1.89E+02	1.23E+02	8.9	-190	2.45E+02	2.00E+00	7.3	310	7.52E+01	1.10E+01	7.5	-190	2.40E+02	3.38E+01
IG_BH05_SO001 (diabase dyke)																			
CR-10 Ox				CR-10 Re				CR-10NF Re				CR-0 Ox				CR-0 Re			
pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error
6.8	300	2.88E+01	4.33E+00	7.4	-210	4.72E+01	4.94E+00	9.1	-200	4.50E+01	9.90E+00	7.5	300	2.84E+01	3.72E+00	7.7	-200	4.36E+01	8.14E+00
6.7	310	2.85E+01	3.77E+00	7.3	-200	4.54E+01	7.09E+00	9.2	-200	4.93E+01	8.05E+00	7.5	300	2.81E+01	4.47E+00	7.8	-200	4.79E+01	7.87E+00
6.9	300	3.00E+01	3.87E+00	7.3	-200	4.75E+01	8.25E+00	9.2	-200	4.69E+01	9.02E+00	7.7	300	3.12E+01	4.61E+00	7.7	-210	4.78E+01	1.02E+01

Table 4-2: Summary of K_d Values of Tc(IV) and Tc(VII) on 5 Core Samples in CR-10, CR-10NF, and CR-0 under Both Oxidizing and Reducing Conditions

IG_BH01_SO001 (biotite granodiorite tonalite)																			
CR-10 Ox				CR-10 Re				CR-10NF Re				CR-0 Ox				CR-0 Re			
pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error
7	300	1.24E+01	9.00E-01	7.1	-200	9.49E+03	4.30E+02	9.3	-200	1.17E+04	4.31E+03	7.6	300	1.76E+01	7.20E+00	7.8	-200	8.96E+03	2.83E+02
7.2	300	1.21E+01	3.00E-01	7.2	-200	1.04E+04	1.76E+03	9.1	-210	8.88E+03	2.88E+03	7.8	300	9.91E+00	4.55E+00	7.8	-200	1.03E+04	3.19E+03
7.1	300	1.20E+01	8.00E-01	7.2	-190	1.06E+04	2.14E+03	9.2	-190	1.19E+04	2.33E+03	7.7	300	1.23E+01	2.20E+00	7.9	-200	1.19E+04	8.40E+02
IG_BH01_SO014 (biotite granodiorite tonalite)																			
CR-10 Ox				CR-10 Re				CR-10NF Re				CR-0 Ox				CR-0 Re			
pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error
7.1	300	1.33E+01	3.00E+00	7.4	-200	1.12E+04	8.90E+02	9.3	-200	9.29E+03	1.39E+03	7.3	300	9.92E+00	4.17E+00	7.7	-200	1.18E+04	1.50E+02
7	300	1.45E+01	6.90E+00	7.2	-200	1.17E+04	5.60E+02	9.2	-210	1.02E+04	1.30E+03	7.4	300	1.03E+01	3.90E+00	7.8	-200	1.27E+04	3.97E+03
6.8	300	1.00E+01	2.20E+00	7.4	-200	8.78E+03	2.12E+03	9.2	-200	8.11E+03	2.36E+03	7.1	300	1.55E+01	9.00E-01	7.8	-200	1.16E+04	1.78E+03
IG_BH03_SO002 (biotite granodiorite tonalite)																			
CR-10 Ox				CR-10 Re				CR-10NF Re				CR-0 Ox				CR-0 Re			
pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error
6.8	300	1.24E+01	1.50E+00	7.4	-200	1.17E+04	1.79E+03	9.2	-200	1.04E+04	2.87E+03	7.2	300	1.30E+01	4.80E+00	7.8	-200	8.91E+03	2.34E+03
6.8	310	1.32E+01	6.00E-01	7.3	-200	1.18E+04	1.05E+03	9.4	-200	1.11E+04	9.50E+02	7.3	300	1.62E+01	6.30E+00	7.7	-210	9.07E+03	1.79E+03
6.9	310	1.03E+01	2.87E+00	7.4	-200	1.06E+04	8.10E+02	9.2	-200	1.08E+04	2.05E+03	7.1	300	1.09E+01	2.30E+00	7.8	-200	1.18E+04	1.41E+03
IG_BH03_SO005 (amphibolite)																			
CR-10 Ox				CR-10 Re				CR-10NF Re				CR-0 Ox				CR-0 Re			
pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error
7	300	3.33E+01	1.24E+01	7.3	-200	2.46E+04	3.47E+03	9.4	-200	2.23E+04	2.74E+03	7.3	300	3.16E+01	1.76E+01	7.9	-200	2.48E+04	2.44E+03
6.8	300	4.76E+01	3.64E+01	7.2	-200	1.92E+04	5.18E+03	9.3	-200	1.94E+04	2.15E+03	7.1	300	2.68E+01	1.01E+01	7.9	-210	2.05E+04	5.87E+03
6.8	300	3.46E+01	7.40E+00	7.1	-200	2.23E+04	7.76E+03	9.4	-200	2.31E+04	6.92E+03	7.1	310	2.77E+01	9.10E+00	7.7	-200	2.45E+04	1.11E+03
IG_BH05_SO001 (diabase dyke)																			
CR-10 Ox				CR-10 Re				CR-10NF Re				CR-0 Ox				CR-0 Re			
pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error
6.8	300	7.04E+00	1.48E+00	7.4	-200	1.00E+04	6.30E+02	9.2	-200	1.02E+04	9.86E+02	7.3	300	8.38E+00	7.57E-01	7.5	-200	1.09E+04	6.50E+02
6.7	300	7.74E+00	1.22E+00	7.3	-200	1.00E+04	8.30E+02	9.4	-210	1.10E+04	7.47E+02	7.4	300	7.06E+00	1.46E+00	7.7	-200	1.12E+04	5.34E+02
6.6	310	6.70E+00	5.40E-01	7.3	-200	1.07E+04	1.03E+03	9.3	-200	1.11E+04	5.89E+02	7.4	300	7.41E+00	1.37E+00	7.8	-210	9.59E+03	3.47E+02

Table 4-3: Summary of K_d Values of Np(IV) and Np(V) on 5 Core Samples in CR-10, CR-10NF, and CR-0 under Both Oxidizing and Reducing Conditions

IG_BH01_SO001 (biotite granodiorite tonalite)																			
CR-10 Ox				CR-10 Re				CR-10NF Re				CR-0 Ox				CR-0 Re			
pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error
6.7	320	1.24E+01	9.10E-01	7.2	-200	8.61E+03	1.90E+03	9.3	-220	8.21E+03	4.02E+02	7.6	320	9.31E+00	1.80E+00	7.4	-200	8.56E+03	3.90E+00
IG_BH01_SO014 (biotite granodiorite tonalite)																			
CR-10 Ox				CR-10 Re				CR-10NF Re				CR-0 Ox				CR-0 Re			
pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error
7.3	300	8.99E+00	1.10E+00	7.3	-210	8.67E+03	9.78E+02	9.1	-210	8.25E+03	1.46E+03	7.4	300	1.14E+01	2.00E-01	7.6	-220	7.90E+03	5.63E+02
IG_BH03_SO002 (biotite granodiorite tonalite)																			
CR-10 Ox				CR-10 Re				CR-10NF Re				CR-0 Ox				CR-0 Re			
pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error
7	290	9.20E+00	1.40E+00	6.9	-180	8.33E+03	5.63E+02	9.2	-210	8.09E+03	6.10E+02	7.7	290	1.06E+01	1.40E+00	7.6	-190	7.88E+03	9.40E+02
7.4	300	8.30E+00	1.70E+00	6.8	-190	8.18E+03	1.12E+03	9.2	-200	7.80E+03	1.28E+03	7.5	300	9.30E+00	2.40E+00	7.5	-200	7.92E+03	5.14E+02
7.1	310	8.70E+00	3.40E+00	7.2	-200	7.31E+03	9.30E+01	8.8	-190	8.79E+03	7.81E+02	7.5	300	1.11E+01	2.00E+00	7.8	-200	8.08E+03	9.79E+02
IG_BH03_SO005 (amphibolite)																			
CR-10 Ox				CR-10 Re				CR-10NF Re				CR-0 Ox				CR-0 Re			
pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error
7.2	300	3.54E+01	2.00E+00	7.2	-190	2.68E+04	1.58E+03	9.3	-200	1.84E+04	1.30E+03	7.7	310	3.67E+01	7.00E+00	7.5	-190	1.92E+04	3.59E+02
7.1	300	3.18E+01	2.70E+00	6.8	-190	1.79E+04	1.72E+03	8.9	-190	1.91E+04	1.05E+03	7.4	300	3.54E+01	4.60E+00	7.6	-190	1.91E+04	4.48E+03
7.3	290	3.21E+01	5.30E+00	7.3	-190	1.95E+04	1.47E+03	8.8	-190	1.65E+04	2.95E+03	7.2	300	3.23E+01	1.20E+00	7.8	-200	1.93E+04	1.08E+03
IG_BH05_SO001 (diabase dyke)																			
CR-10 Ox				CR-10 Re				CR-10NF Re				CR-0 Ox				CR-0 Re			
pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error
6.7	310	8.29E+00	8.27E-01	7.4	-200	2.74E+03	5.10E+01	9.1	-210	2.94E+03	2.65E+02	7.3	300	8.77E+00	1.04E+00	7.6	-200	3.49E+03	3.94E+02
7	300	8.91E+00	1.25E+00	7.2	-200	3.31E+03	6.20E+02	9.1	-200	3.20E+03	6.29E+02	7.4	310	8.67E+00	6.70E-01	7.7	-210	2.75E+03	1.72E+02
6.8	310	8.50E+00	8.00E-01	7.3	-200	3.08E+03	4.24E+02	9.2	-200	3.06E+03	2.55E+02	7.3	300	7.83E+00	3.84E-01	7.6	-200	3.30E+03	4.82E+02

Table 4-4: Summary of K_d Values of U(IV) and U(VI) on 5 Core Samples in CR-10, CR-10NF, and CR-0 under Both Oxidizing and Reducing Conditions

IG_BH01_SO001 (biotite granodiorite tonalite)																			
CR-10 Ox				CR-10 Re				CR-10NF Re				CR-0 Ox				CR-0 Re			
pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error
6.7	300	9.74E+01	4.67E+00	7.2	-200	9.66E+03	6.93E+02	9.3	-200	9.26E+03	1.02E+02	7.2	300	9.26E+01	4.43E+00	7.8	-200	9.42E+03	2.92E+02
6.6	300	9.88E+01	2.79E+00	7.3	-200	8.84E+03	3.21E+02	9.3	-200	9.34E+03	4.01E+02	7.1	300	9.58E+01	3.64E+00	7.8	-200	9.14E+03	3.76E+02
6.6	300	9.74E+01	1.78E+00	7.2	-200	9.79E+03	4.94E+02	9.4	-200	9.70E+03	3.62E+02	7.2	300	9.89E+01	2.67E+00	7.7	-200	9.37E+03	2.57E+02
IG_BH01_SO014 (biotite granodiorite tonalite)																			
CR-10 Ox				CR-10 Re				CR-10NF Re				CR-0 Ox				CR-0 Re			
pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error
6.7	300	9.56E+01	3.84E+00	7.3	-200	9.97E+03	1.82E+02	9.3	-200	9.07E+03	9.75E+01	7.2	300	9.30E+01	1.83E+00	7.7	-200	9.94E+03	1.86E+02
6.6	300	8.97E+01	1.71E+00	7.3	-200	9.15E+03	2.18E+02	9.4	-200	9.29E+03	2.31E+02	7.2	300	9.07E+01	2.28E+00	7.6	-200	1.00E+04	2.69E+02
6.7	300	9.62E+01	2.36E+00	7.3	-200	9.41E+03	2.71E+02	9.4	-200	9.38E+03	2.13E+02	7.1	300	9.35E+01	3.31E+00	7.8	-200	9.62E+03	1.46E+02
IG_BH03_SO002 (biotite granodiorite tonalite)																			
CR-10 Ox				CR-10 Re				CR-10NF Re				CR-0 Ox				CR-0 Re			
pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error
6.8	300	1.00E+02	1.01E+01	7.4	-200	1.02E+04	1.09E+03	9.4	-200	9.19E+03	3.31E+02	7.1	300	1.03E+02	1.23E+01	7.8	-200	1.01E+04	6.07E+02
6.7	300	1.05E+02	6.14E+00	7.4	-200	9.45E+03	6.15E+02	9.3	-200	9.49E+03	9.66E+02	7.2	300	9.13E+01	6.40E+00	7.7	-200	8.91E+03	4.21E+02
6.6	300	9.39E+01	8.96E+00	7.2	-200	8.90E+03	4.01E+02	9.3	-200	9.85E+03	4.32E+02	7.2	300	9.01E+01	4.16E+00	7.8	-200	1.03E+04	6.83E+02
IG_BH03_SO005 (amphibolite)																			
CR-10 Ox				CR-10 Re				CR-10NF Re				CR-0 Ox				CR-0 Re			
pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error
6.8	300	2.16E+02	4.20E+01	7.4	-200	2.16E+04	3.65E+03	9.4	-200	1.94E+04	1.53E+03	7.3	300	2.04E+02	1.46E+01	7.7	-200	2.01E+04	1.24E+03
6.6	310	2.12E+02	4.09E+01	7.4	-200	2.23E+04	1.94E+03	9.3	-200	1.85E+04	1.65E+03	7.2	310	2.21E+02	3.36E+01	7.6	-200	2.03E+04	1.92E+03
6.6	310	2.16E+02	2.30E+01	7.3	-200	2.16E+04	3.28E+03	9.2	-200	2.54E+04	3.61E+03	7.3	300	1.93E+02	1.51E+01	7.7	-200	2.29E+04	1.80E+03
IG_BH05_SO001 (diabase dyke)																			
CR-10 Ox				CR-10 Re				CR-10NF Re				CR-0 Ox				CR-0 Re			
pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error
6.6	310	6.96E+01	4.59E+00	7.5	-210	6.98E+03	6.07E+02	9.4	-200	6.99E+03	4.39E+02	7.1	300	6.71E+01	1.74E+00	7.7	-200	7.10E+03	5.59E+02
6.6	300	6.94E+01	3.52E+00	7.4	-200	6.98E+03	5.90E+02	9.3	-200	7.45E+03	3.86E+02	7.2	300	7.06E+01	4.27E+00	7.8	-200	6.96E+03	5.06E+02
6.7	300	7.05E+01	4.78E+00	7.4	-200	7.48E+03	2.01E+02	9.4	-200	7.35E+03	4.19E+02	7.2	300	6.90E+01	4.69E+00	7.7	-200	6.76E+03	2.77E+02

Table 4-5: Summary of K_d Values of Eu on 5 Core Samples in CR-10, CR-10NF, and CR-0 under Both Oxidizing and Reducing Conditions

IG_BH01_SO001 (biotite granodiorite tonalite)																			
CR-10 Ox				CR-10 Re				CR-10NF Re				CR-0 Ox				CR-0 Re			
pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error
7.3	300	1.63E+03	1.60E+02	7.2	-210	1.70E+03	1.12E+02	9.2	-200	1.53E+03	6.51E+01	7.4	300	1.61E+03	8.52E+01	7.5	-200	1.58E+03	1.42E+02
7.2	300	1.58E+03	5.55E+01	7.1	-200	1.64E+03	2.22E+02	9.3	-210	1.43E+03	1.07E+02	7.3	300	1.56E+03	5.33E+01	7.7	-200	1.70E+03	1.18E+02
7.1	310	1.47E+03	2.00E+02	7.3	-200	1.39E+03	5.31E+02	9.2	-200	1.67E+03	2.90E+02	7.4	300	1.40E+03	1.59E+02	7.6	-200	1.62E+03	1.19E+02
IG_BH01_SO014 (biotite granodiorite tonalite)																			
CR-10 Ox				CR-10 Re				CR-10NF Re				CR-0 Ox				CR-0 Re			
pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error
6.9	310	1.70E+03	1.10E+02	7.2	-200	1.72E+03	2.70E+02	9.3	-200	1.84E+03	2.86E+02	7.4	300	1.37E+03	4.29E+02	7.7	-210	2.13E+03	2.79E+02
7.1	300	1.55E+03	2.07E+02	7.4	-210	1.79E+03	2.56E+02	9.2	-200	1.78E+03	1.57E+02	7.1	310	1.71E+03	1.42E+02	7.5	-200	1.75E+03	1.82E+02
7.1	300	1.63E+03	1.89E+02	7.3	-200	1.78E+03	2.91E+01	9.2	-200	1.63E+03	1.47E+02	7.2	300	1.58E+03	9.79E+01	7.6	-200	1.86E+03	1.71E+02
IG_BH03_SO002 (biotite granodiorite tonalite)																			
CR-10 Ox				CR-10 Re				CR-10NF Re				CR-0 Ox				CR-0 Re			
pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error
6.7	300	2.20E+03	5.48E+02	7.3	-200	2.20E+03	2.78E+02	9.3	-200	1.65E+03	1.13E+02	7.2	300	2.98E+03	2.34E+02	7.8	-200	1.65E+03	2.05E+02
6.8	300	1.91E+03	2.32E+02	7.2	-200	2.02E+03	5.15E+02	9.2	-200	1.90E+03	3.37E+01	7.2	300	2.08E+03	4.94E+02	7.7	-200	1.65E+03	2.78E+02
6.6	300	1.97E+03	2.76E+02	7.4	-210	2.26E+03	2.73E+02	9.2	-200	1.64E+03	6.06E+02	7.4	300	1.52E+03	6.13E+02	7.7	-190	1.71E+03	1.95E+02
IG_BH03_SO005 (amphibolite)																			
CR-10 Ox				CR-10 Re				CR-10NF Re				CR-0 Ox				CR-0 Re			
pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error
7.1	300	3.50E+03	6.32E+02	7.3	-200	4.34E+03	2.85E+03	9.2	-200	3.01E+03	1.77E+03	7.2	300	3.24E+03	6.59E+02	7.8	-210	3.65E+03	7.87E+02
6.7	300	2.75E+03	2.40E+02	7.3	-210	3.10E+03	3.63E+02	9.3	-200	3.69E+03	1.07E+03	7.1	300	4.54E+03	1.61E+03	7.7	-200	4.45E+03	1.09E+03
6.9	300	3.15E+03	2.35E+02	7.1	-200	3.38E+03	2.55E+02	9.3	-200	3.19E+03	4.45E+02	7.3	300	3.37E+03	5.57E+02	7.5	-200	5.05E+03	1.43E+03
IG_BH05_SO001 (diabase dyke)																			
CR-10 Ox				CR-10 Re				CR-10NF Re				CR-0 Ox				CR-0 Re			
pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error	pH	Eh (mV)	K_d (mL/g)	error
6.8	300	1.06E+03	1.20E+02	7.3	-200	9.75E+02	6.15E+01	9.5	-200	1.04E+03	1.14E+02	7.6	300	1.09E+03	6.39E+01	7.8	-200	1.08E+03	1.03E+02
6.7	300	1.08E+03	1.11E+02	7.3	-200	1.04E+03	1.39E+02	9.2	-200	1.04E+03	1.38E+02	7.5	300	9.85E+02	7.88E+01	7.9	-210	9.94E+02	6.26E+01
6.9	300	1.06E+03	1.38E+02	7.4	-200	1.09E+03	1.06E+02	9.4	-210	1.00E+03	1.28E+02	7.7	300	1.11E+03	2.98E+01	7.6	-200	1.03E+03	1.25E+02

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Table A-1: Sorption kinetics data of Se on IG_BH01_SO001 (biotite granodiorite tonalite) in CR-10 (Oxidizing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	6.8	7.1	350	330	2.62E+01	1.13E+01	1.49E+01	3.65E+01
2	6.7	6.9	340	350	8.62E+01	5.49E+01	4.29E+01	1.41E+02
3	6.8	7	350	320	5.77E+01	1.33E+01	4.44E+01	6.87E+01
7	7.1	6.8	330	300	6.77E+01	5.60E+00	6.41E+01	7.33E+01
14	6.9	7.2	340	330	7.61E+01	2.22E+01	5.67E+01	9.83E+01
21	7.2	7.3	330	310	6.12E+01	1.34E+01	4.78E+01	7.33E+01

Table A-2: Sorption kinetics data of Se on IG_BH01_SO001 (biotite granodiorite tonalite) in CR-10 (Reducing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	7.1	7.2	-200	-200	2.57E+01	8.00E+00	1.77E+01	3.26E+01
2	7.1	7.3	-200	-210	7.12E+01	2.63E+01	5.80E+01	9.75E+01
3	6.8	7.1	-240	-220	7.94E+01	3.51E+01	5.02E+01	1.15E+02
7	6.9	7.5	-210	-210	1.04E+02	1.46E+01	8.90E+01	1.19E+02
14	7.2	7.4	-200	-210	1.08E+02	7.10E+00	1.02E+02	1.15E+02
21	7.1	7.3	-200	-220	1.10E+02	6.50E+00	1.06E+02	1.16E+02

Table A-3: Sorption kinetics data of Se on IG_BH01_SO001 (biotite granodiorite tonalite) in CR-10NF (Reducing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	8.8	9.2	-200	-200	2.23E+01	5.30E+00	1.70E+01	2.53E+01
2	8.9	9.1	-210	-210	1.04E+02	1.10E+01	9.83E+01	1.15E+02
3	9	9.2	-200	-210	9.91E+01	1.20E+00	9.82E+01	1.00E+02
7	9	9.3	-200	-200	1.01E+02	2.30E+00	9.93E+01	1.03E+02
14	8.8	9	-220	-210	1.06E+02	9.10E+00	9.81E+01	1.15E+02
21	9.1	9.3	-200	-200	1.09E+02	1.20E+00	1.08E+02	1.10E+02

Table A-4: Sorption kinetics data of Se on IG_BH01_SO001 (biotite granodiorite tonalite) in CR-0 (Oxidizing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	7.2	7.4	330	330	3.87E+01	1.89E+01	2.39E+01	5.76E+01
2	7.3	7.3	300	320	5.61E+01	2.24E+01	3.85E+01	7.85E+01
3	7.2	7.2	320	330	5.01E+01	1.72E+01	3.29E+01	6.52E+01
7	7.2	7.2	300	310	5.89E+01	1.88E+01	4.50E+01	7.77E+01
14	7.4	7.3	310	300	4.78E+01	3.60E+00	4.53E+01	5.14E+01
21	7.1	7.4	300	300	5.13E+01	1.62E+01	4.18E+01	6.75E+01

Table A-5: Sorption kinetics data of Se on IG_BH01_SO001 (biotite granodiorite tonalite) in CR-0 (Reducing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	7.2	7.7	-200	-210	3.01E+01	2.01E+01	1.00E+01	4.16E+01
2	7.2	7.5	-210	-200	1.17E+02	3.63E+01	8.43E+01	1.53E+02
3	7.1	7.6	-200	-210	1.12E+02	1.05E+01	1.01E+02	1.20E+02
7	7.3	7.7	-220	-200	1.05E+02	1.26E+01	9.28E+01	1.15E+02
14	7.4	7.8	-200	-200	PF	PF	PF	PF
21	7.3	7.6	-210	-210	PF	PF	PF	PF

PF: pump failure, No data

Table A-6: Sorption kinetics data of Se on IG_BH05_SO001 (diabase dyke) in CR-10 (Oxidizing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	6.7	6.8	310	300	7.95E+00	1.31E+00	6.64E+00	8.83E+00
2	6.8	6.6	300	300	2.63E+01	6.75E+00	1.96E+01	3.18E+01
3	6.6	6.7	300	300	2.76E+01	2.34E+00	2.53E+01	2.92E+01
7	6.7	6.9	300	300	2.99E+01	5.15E+00	2.70E+01	3.50E+01
14	6.9	6.8	300	300	2.61E+01	5.40E+00	2.32E+01	3.15E+01
21	6.8	7.1	300	300	2.84E+01	2.73E+00	2.61E+01	3.12E+01

Table A-7: Sorption kinetics data of Se on IG_BH05_SO001 (diabase dyke) in CR-10 (Reducing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	7.4	7.2	-200	-200	8.22E+00	3.11E+00	5.11E+00	1.12E+01
2	7.4	7.1	-200	-200	3.12E+01	1.17E+01	2.48E+01	4.29E+01
3	7.3	7.4	-200	-200	3.14E+01	1.04E+01	2.22E+01	4.18E+01
7	7.4	7.3	-200	-200	4.82E+01	6.08E+00	4.21E+01	5.29E+01
14	7.4	7.2	-200	-200	4.83E+01	2.76E+00	4.56E+01	4.99E+01
21	7.3	7.4	-200	-200	4.88E+01	4.90E+00	4.59E+01	5.37E+01

Table A-8: Sorption kinetics data of Se on IG_BH05_SO001 (diabase dyke) in CR-10NF (Reducing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	9.2	9.3	-210	-200	1.00E+01	5.71E+00	5.70E+00	1.57E+01
2	9.1	9.5	-210	-200	4.67E+01	5.82E+00	4.29E+01	5.25E+01
3	9.2	9.4	-200	-200	4.30E+01	2.74E+00	4.03E+01	4.52E+01
7	9.3	9.3	-200	-200	4.36E+01	2.63E+00	4.13E+01	4.62E+01
14	9.4	9.4	-210	-200	4.35E+01	1.97E+00	4.15E+01	4.49E+01
21	9.2	9.4	-200	-200	4.55E+01	2.31E+00	4.32E+01	4.68E+01

Table A-9: Sorption kinetics data of Se on IG_BH05_SO001 (diabase dyke) in CR-0 (Oxidizing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	7.3	7.4	300	300	1.04E+01	3.45E+00	6.92E+00	1.23E+01
2	7.2	7.3	310	300	2.81E+01	5.14E+00	2.30E+01	3.31E+01
3	7.3	7.2	300	300	2.73E+01	6.15E+00	2.12E+01	3.27E+01
7	7.1	7.3	300	300	2.84E+01	1.92E+00	2.73E+01	3.03E+01
14	7.2	7.4	300	300	2.43E+01	4.58E+00	1.98E+01	2.89E+01
21	7.2	7.5	300	300	2.66E+01	2.00E+00	2.46E+01	2.80E+01

Table A-10: Sorption kinetics data of Se on IG_BH05_SO001 (diabase dyke) in CR-0 (Reducing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	7.6	7.8	-210	-200	1.26E+01	4.51E+00	8.05E+00	1.45E+01
2	7.5	7.7	-200	-200	5.27E+01	1.93E+01	3.63E+01	7.20E+01
3	7.7	7.9	-200	-200	4.70E+01	7.55E+00	4.29E+01	5.45E+01
7	7.6	7.6	-200	-200	4.03E+01	2.23E+00	3.81E+01	4.21E+01
14	7.8	7.5	-200	-200	4.50E+01	3.50E+00	4.18E+01	4.85E+01
21	7.7	7.8	-200	-210	4.28E+01	4.46E+00	3.83E+01	4.68E+01

Table A-11: K_d measurement data of Se on IG_BH01_SO001 (biotite granodiorite tonalite)

Solution Ox/Re	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
CR-10_OX	7.2	7.2	310	320	5.61E+01	1.94E+01	4.50E+01	7.55E+01
CR-10_RE	7.3	7.3	-210	-200	1.16E+02	1.57E+01	1.01E+02	1.32E+02
CR-10NF_RE	9	9	-200	-210	1.10E+02	4.40E+00	1.07E+02	1.14E+02
CR-0_OX	7.4	7.4	300	300	5.88E+01	2.05E+01	4.35E+01	7.93E+01
CR-0_RE	7.6	7.3	-220	-210	1.10E+02	3.90E+00	1.07E+02	1.14E+02

Table A-12: K_d measurement data of Se on IG_BH01_SO014 (biotite granodiorite tonalite)

Solution Ox/Re	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
CR-10_OX	6.8	7.1	320	310	5.88E+01	1.26E+01	4.62E+01	6.94E+01
CR-10_RE	7.2	7.2	-220	-210	1.28E+02	1.10E+00	1.27E+02	1.29E+02
CR-10NF_RE	8.9	9	-200	-200	1.19E+02	2.30E+01	1.02E+02	1.42E+02
CR-0_OX	7.5	7.6	310	310	6.27E+01	1.25E+01	5.02E+01	7.26E+01
CR-0_RE	7.5	7.5	-200	-200	1.08E+02	1.78E+01	9.34E+01	1.26E+02

Table A-13: K_d measurement data of Se on IG_BH03_SO002 (biotite granodiorite tonalite)

Solution Ox/Re	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
CR-10_OX	6.8	7.2	300	300	6.78E+01	3.00E-01	6.75E+01	6.81E+01
CR-10_OX	6.7	7.1	310	300	9.07E+01	7.10E+00	8.43E+01	9.79E+01
CR-10_OX	7.1	6.9	300	310	5.32E+01	1.09E+01	4.41E+01	6.41E+01
CR-10_RE	7.1	7	-200	-200	1.31E+02	4.89E+01	1.03E+02	1.79E+02
CR-10_RE	6.9	6,9	-210	-200	1.30E+02	3.65E+01	1.11E+02	1.66E+02
CR-10_RE	7.1	7.2	-200	-200	1.09E+02	2.20E+00	1.08E+02	1.11E+02
CR-10NF_RE	9.2	9.2	-210	-200	1.30E+02	3.91E+01	1.08E+02	1.69E+02
CR-10NF_RE	9	9	-200	-190	1.09E+02	4.20E+00	1.06E+02	1.13E+02
CR-10NF_RE	8.9	8.9	-200	-200	1.06E+02	2.00E+00	1.04E+02	1.08E+02
CR-0_OX	7.6	7.6	300	310	5.64E+01	8.80E+00	4.99E+01	6.52E+01
CR-0_OX	7.5	7.7	310	300	5.10E+01	2.16E+01	3.67E+01	7.26E+01
CR-0_OX	7.5	7.4	300	290	4.78E+01	2.10E+01	3.33E+01	6.87E+01
CR-0_RE	7.7	7.5	-210	-190	1.04E+02	1.10E+01	9.27E+01	1.11E+02
CR-0_RE	7.6	7.4	-200	-190	1.24E+02	1.86E+01	1.06E+02	1.40E+02
CR-0_RE	7.5	7.7	-210	-200	1.07E+02	6.90E+00	1.03E+02	1.14E+02

Table A-14: K_d measurement data of Se on IG_BH03_SO005 (amphibolite)

Solution Ox/Re	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
CR-10_OX	6.8	7.3	320	300	6.44E+01	1.99E+01	5.17E+01	8.43E+01
CR-10_OX	7.2	6.8	310	310	7.89E+01	2.00E+01	5.90E+01	9.35E+01
CR-10_OX	7.2	7.1	330	300	6.96E+01	3.00E+00	7.26E+01	6.69E+01
CR-10_RE	7	6.8	-210	-200	2.35E+02	8.17E+01	1.53E+02	3.13E+02
CR-10_RE	7.1	6.9	-200	-190	2.16E+02	7.89E+01	1.17E+02	2.90E+02
CR-10_RE	6.9	7.2	-210	-200	1.89E+02	1.23E+02	1.16E+02	3.12E+02
CR-10NF_RE	9.2	9.1	-200	-210	2.45E+02	1.02E+02	1.43E+02	3.02E+02
CR-10NF_RE	9	9.4	-210	-200	2.46E+02	1.28E+02	1.19E+02	3.19E+02
CR-10NF_RE	9	8.9	-200	-190	2.45E+02	2.00E+00	2.44E+02	2.47E+02
CR-0_OX	7.3	7.6	310	300	9.68E+01	5.69E+01	4.05E+01	1.54E+02
CR-0_OX	7.2	7.4	300	300	8.00E+01	5.20E+00	7.55E+01	8.52E+01
CR-0_OX	7	7.3	300	310	7.52E+01	1.10E+01	6.46E+01	8.62E+01
CR-0_RE	7.3	7.7	-200	-190	3.62E+02	1.48E+02	2.14E+02	4.43E+02
CR-0_RE	7.3	7.3	-200	-190	2.02E+02	2.97E+01	1.73E+02	2.26E+02
CR-0_RE	7.2	7.5	-200	-190	2.40E+02	3.38E+01	2.07E+02	2.62E+02

Table A-15: K_d measurement data of Se on IG_BH05_SO001 (diabase dyke)

Solution Ox/Re	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
CR-10_OX	6.9	6.8	310	300	2.88E+01	4.33E+00	2.53E+01	3.31E+01
CR-10_OX	6.8	6.7	300	310	2.85E+01	3.77E+00	2.47E+01	3.18E+01
CR-10_OX	6.8	6.9	310	300	3.00E+01	3.87E+00	2.69E+01	3.39E+01
CR-10_RE	7.3	7.4	-200	-210	4.72E+01	4.94E+00	4.29E+01	5.21E+01
CR-10_RE	7.4	7.3	-210	-200	4.54E+01	7.09E+00	3.88E+01	5.25E+01
CR-10_RE	7.3	7.3	-200	-200	4.75E+01	8.25E+00	3.93E+01	5.41E+01
CR-10NF_RE	8.9	9.1	-210	-200	4.50E+01	9.90E+00	3.81E+01	5.49E+01
CR-10NF_RE	9.2	9.2	-220	-200	4.93E+01	8.05E+00	4.13E+01	5.54E+01
CR-10NF_RE	9.1	9.2	-210	-200	4.69E+01	9.02E+00	3.79E+01	5.49E+01
CR-0_OX	7.4	7.5	300	300	2.84E+01	3.72E+00	2.47E+01	3.18E+01
CR-0_OX	7.4	7.5	300	300	2.81E+01	4.47E+00	2.56E+01	3.26E+01
CR-0_OX	7.5	7.7	300	300	3.12E+01	4.61E+00	2.66E+01	3.53E+01
CR-0_RE	7.8	7.7	-210	-200	4.36E+01	8.14E+00	3.88E+01	5.17E+01
CR-0_RE	7.7	7.8	-210	-200	4.79E+01	7.87E+00	4.05E+01	5.58E+01
CR-0_RE	7.8	7.7	-210	-210	4.78E+01	1.02E+01	3.76E+01	5.45E+01

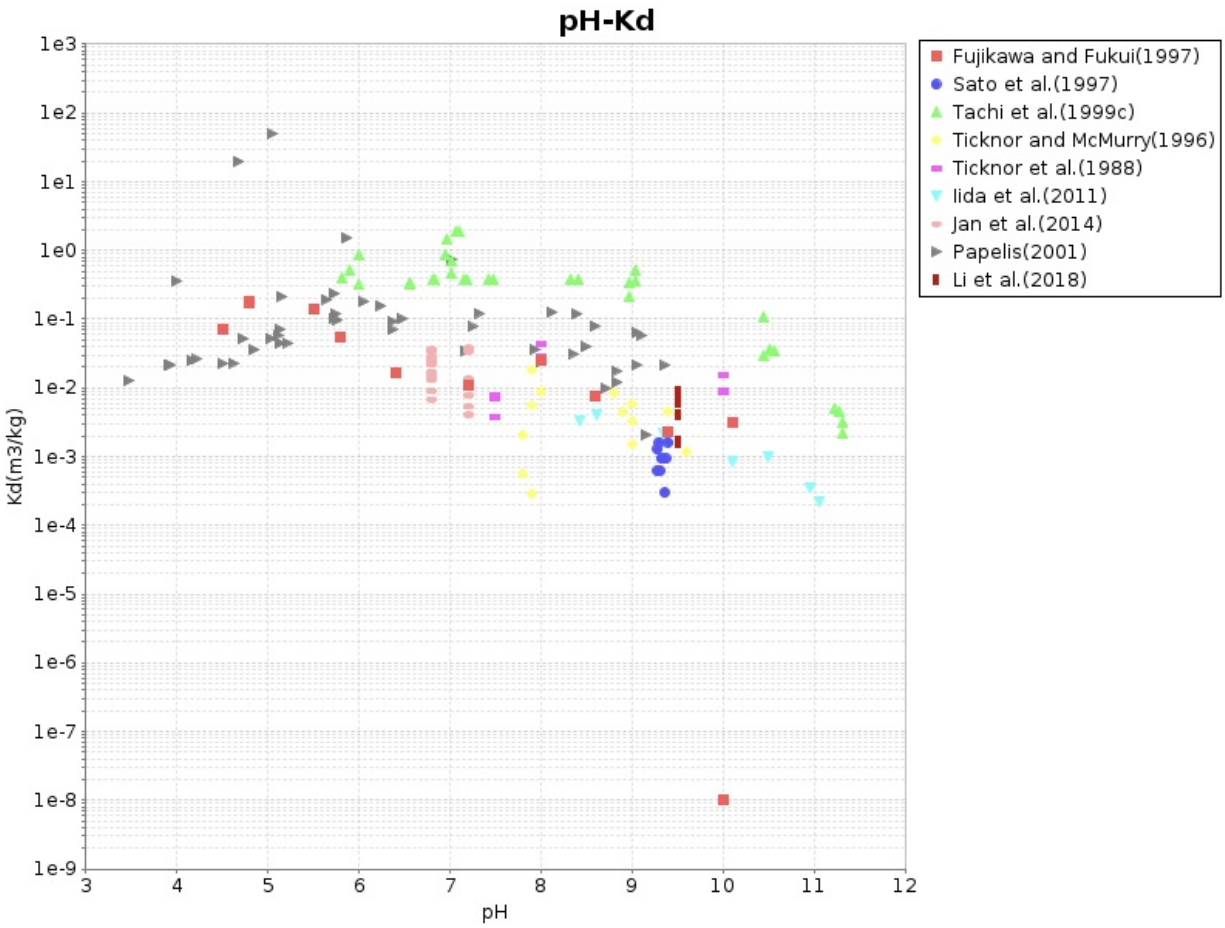


Figure A-1: K_d of Se on granite compiled in JAEA database (pH dependence)

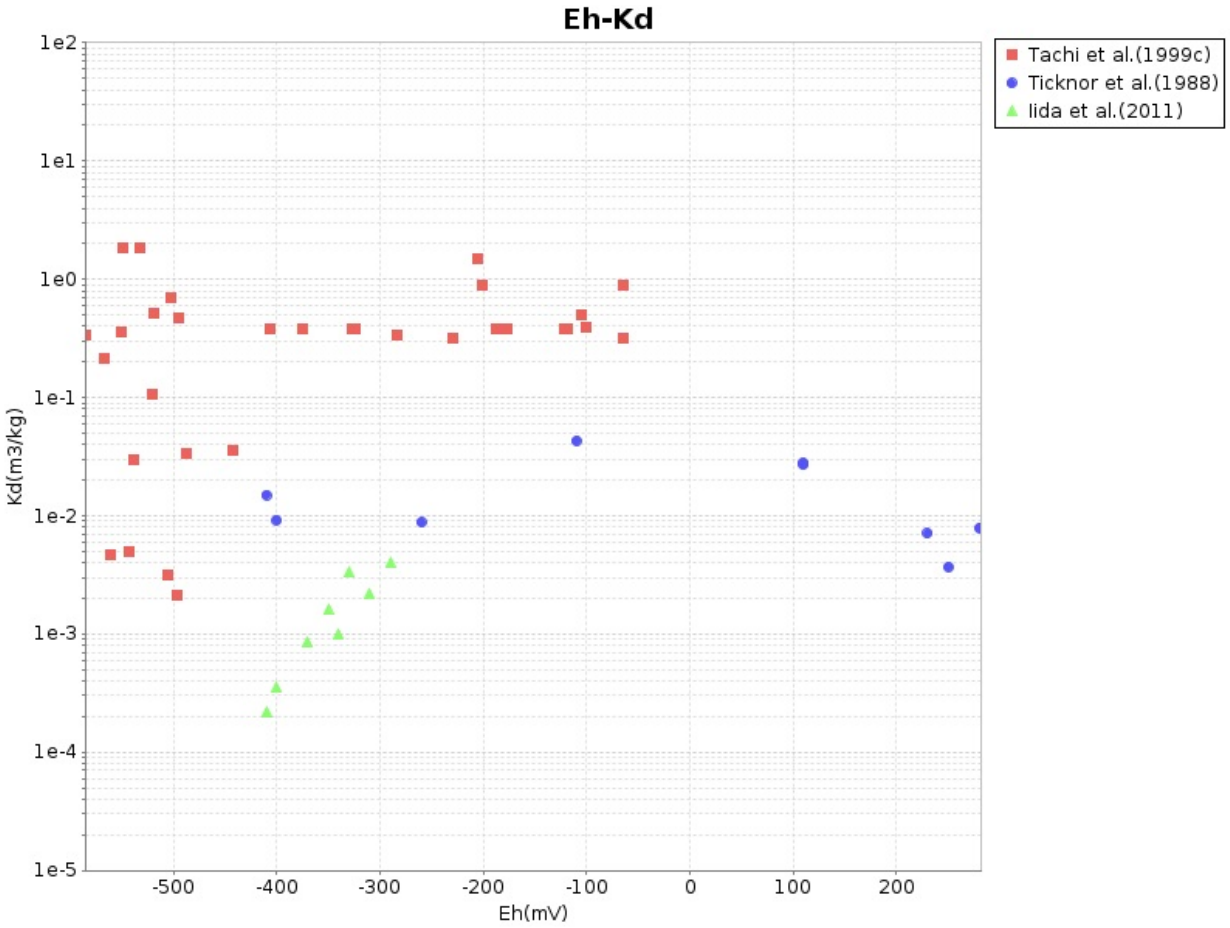


Figure A-2: K_d of Se on granite compiled in JAEA database (Eh dependence)

Table A-16: Sorption kinetics data of Tc on IG_BH01_SO001 (biotite granodiorite tonalite) in CR-10 (Oxidizing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	7.2	7.2	300	300	1.33E+00	5.60E-01	9.40E-01	1.89E+00
2	7.2	7.1	300	310	1.12E+01	4.00E+00	7.28E+00	1.52E+01
3	7.2	7.2	300	300	1.25E+01	3.20E+00	1.02E+01	1.57E+01
7	7.2	7.3	300	300	1.15E+01	3.80E+00	9.46E+00	1.53E+01
14	7.2	7.2	300	300	1.40E+01	2.70E+00	1.13E+01	1.62E+01

Table A-17: Sorption kinetics data of Tc on IG_BH01_SO001 (biotite granodiorite tonalite) in CR-10 (Reducing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	6.9	6.9	-210	-210	3.21E+02	1.54E+02	2.26E+02	4.75E+02
2	6.9	7.1	-210	-210	1.00E+04	6.12E+03	5.82E+03	1.61E+04
3	6.9	6.9	-210	-210	1.45E+04	5.78E+03	1.12E+04	2.03E+04
7	6.9	7	-210	-200	1.21E+04	2.19E+03	1.02E+04	1.43E+04
14	6.9	7.2	-210	-200	1.35E+04	3.82E+03	1.16E+04	1.73E+04

Table A-18: Sorption kinetics data of Tc on IG_BH01_SO001 (biotite granodiorite tonalite) in CR-10NF (Reducing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	9.1	9.1	-200	-200	4.65E+02	1.69E+02	3.30E+01	6.34E+02
2	9.1	9.2	-200	-210	1.38E+04	3.19E+03	1.17E+04	1.70E+04
3	9.1	9.2	-200	-220	1.26E+04	3.21E+03	9.40E+03	1.57E+04
7	9.1	9	-200	-210	1.54E+04	9.75E+03	1.13E+04	1.82E+04
14	9.1	9.1	-200	-210	1.36E+04	8.58E+03	9.94E+03	1.64E+04

Table A-19: Sorption kinetics data of Tc on IG_BH01_SO001 (biotite granodiorite tonalite) in CR-0 (Oxidizing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	7.5	7.5	310	310	1.18E+01	1.50E+00	1.10E+01	1.33E+01
2	7.5	7.5	310	320	1.21E+01	3.00E+00	1.02E+01	1.51E+01
3	7.5	7.4	310	300	1.19E+01	4.20E+00	8.65E+00	1.61E+01
7	7.5	7.6	310	310	1.32E+01	2.10E+00	1.19E+01	1.53E+01
14	7.5	7.5	310	300	7.62E+00	6.00E+00	4.11E+00	1.36E+01

Table A-20: Sorption kinetics data of Tc on IG_BH01_SO001 (biotite granodiorite tonalite) in CR-0 (Reducing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	7.4	7.4	-210	-210	5.46E+03	7.94E+02	4.79E+03	6.26E+03
2	7.4	7.3	-210	-200	1.50E+04	1.96E+03	1.30E+04	1.68E+04
3	7.4	7.5	-210	-200	1.31E+04	2.96E+03	1.11E+04	1.61E+04
7	7.4	7.4	-210	-200	1.38E+04	6.74E+03	8.12E+03	1.91E+04
14	7.4	7.3	-210	-190	1.26E+04	6.39E+03	6.22E+03	1.65E+04

Table A-21: Sorption kinetics data of Tc on IG_BH05_SO001 (diabase dyke) in CR-10 (Oxidizing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	6.8	6.6	300	300	2.76E+00	5.04E-01	2.39E+00	3.27E+00
2	6.7	6.9	300	300	5.20E+00	3.19E+00	2.78E+00	8.39E+00
3	6.5	6.7	300	300	6.02E+00	2.54E+00	3.82E+00	8.56E+00
7	6.7	7	300	300	6.89E+00	3.69E+00	3.20E+00	8.96E+00
14	6.9	7.2	300	300	8.34E+00	1.41E+00	7.58E+00	9.75E+00
21	6.8	6.6	300	300	9.04E+00	1.10E+00	7.94E+00	1.01E+01

Table A-22: Sorption kinetics data of Tc on IG_BH05_SO001 (diabase dyke) in CR-10 (Reducing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	7.3	7.4	-200	-200	5.86E+03	7.51E+02	5.11E+03	6.55E+03
2	7.4	7.2	-210	-200	7.78E+03	3.94E+03	5.44E+03	1.17E+04
3	7.2	7.3	-200	-200	1.05E+04	6.33E+03	6.90E+03	1.69E+04
7	7.3	7.1	-200	-200	8.30E+03	1.60E+03	6.72E+03	9.89E+03
14	7.4	7.5	-200	-200	9.56E+03	2.67E+03	7.42E+03	1.22E+04
21	7.3	7.3	-200	-200	1.00E+04	1.59E+03	8.94E+03	1.16E+04

Table A-23: Sorption kinetics data of Tc on IG_BH05_SO001 (diabase dyke) in CR-10NF (Reducing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	8.9	9.2	-200	-200	6.07E+03	4.82E+02	5.59E+03	6.51E+03
2	8.8	9.1	-190	-200	9.50E+03	3.16E+03	7.55E+03	1.24E+04
3	9	9.3	-200	-190	9.20E+03	2.21E+03	7.90E+03	1.14E+04
7	9.1	9.4	-200	-200	1.11E+04	4.22E+03	6.90E+03	1.46E+04
14	9.3	9.2	-210	-200	1.08E+04	1.78E+03	9.64E+03	1.26E+04
21	9.2	9.3	-200	-190	9.47E+03	1.51E+03	7.96E+03	1.06E+04

Table A-24: Sorption kinetics data of Tc on IG_BH05_SO001 (diabase dyke) in CR-0 (Oxidizing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	7.3	7.5	300	300	8.55E-01	6.72E-01	4.99E-01	1.53E+00
2	7.4	7.2	310	300	6.21E+00	2.02E+00	4.34E+00	8.22E+00
3	7.3	7.1	300	300	5.77E+00	3.70E+00	2.74E+00	9.46E+00
7	7.3	7.3	300	300	6.45E+00	2.02E+00	5.04E+00	8.48E+00
14	7.5	7.4	300	300	6.60E+00	2.83E+00	3.77E+00	8.26E+00
21	7.3	7.2	300	300	6.41E+00	2.26E-01	6.27E+00	6.63E+00

Table A-25: Sorption kinetics data of Tc on IG_BH05_SO001 (diabase dyke) in CR-0 (Reducing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	7.8	7.7	-210	-200	5.43E+03	7.93E+02	4.66E+03	6.23E+03
2	7.7	7.9	-200	-200	9.39E+03	6.75E+02	8.75E+03	1.01E+04
3	7.8	8	-200	-200	8.21E+03	9.14E+02	7.29E+03	9.10E+03
7	7.8	7.8	-210	-200	1.00E+04	1.68E+03	9.02E+03	1.17E+04
14	7.6	7.9	-200	-200	8.51E+03	8.72E+02	7.64E+03	9.10E+03
21	7.7	7.5	-200	-200	9.27E+03	3.64E+02	8.98E+03	9.64E+03

Table A-26: K_d measurement data of Tc on IG_BH01_SO001 (biotite granodiorite tonalite)

Solution Ox/Re	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
CR-10_OX	7	7	300	300	1.24E+01	9.00E-01	1.17E+01	1.33E+01
CR-10_OX	7.1	7.2	310	300	1.21E+01	3.00E-01	1.18E+01	1.24E+01
CR-10_OX	7.2	7.1	300	300	1.20E+01	8.00E-01	1.12E+01	1.23E+01
CR-10_RE	6.9	7.1	-210	-200	9.49E+03	4.30E+02	9.06E+03	9.71E+03
CR-10_RE	7.2	7.2	-200	-200	1.04E+04	1.76E+03	8.82E+03	1.21E+04
CR-10_RE	7.1	7.2	-210	-190	1.06E+04	2.14E+03	9.08E+03	1.27E+04
CR-10NF_RE	9	9.3	-200	-200	1.17E+04	4.31E+03	8.86E+03	1.60E+04
CR-10NF_RE	8.8	9.1	-210	-210	8.88E+03	2.88E+03	6.14E+03	1.18E+04
CR-10NF_RE	9.1	9.2	-200	-190	1.19E+04	2.33E+03	9.57E+03	1.42E+04
CR-0_OX	7.6	7.6	310	300	1.76E+01	7.20E+00	1.27E+01	2.48E+01
CR-0_OX	7.5	7.8	300	300	9.91E+00	4.55E+00	5.36E+00	1.30E+01
CR-0_OX	7.5	7.7	310	300	1.23E+01	2.20E+00	1.11E+01	1.45E+01
CR-0_RE	7.4	7.8	-210	-200	8.96E+03	2.83E+02	8.73E+03	9.25E+03
CR-0_RE	7.8	7.8	-200	-200	1.03E+04	3.19E+03	8.14E+03	1.35E+04
CR-0_RE	7.6	7.9	-210	-200	1.19E+04	8.40E+02	1.15E+04	1.27E+04

Table A-27: K_d measurement data of Tc on IG_BH01_SO014 (biotite granodiorite tonalite)

Solution Ox/Re	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
CR-10_OX	6.8	7.1	300	300	1.33E+01	3.00E+00	1.16E+01	1.63E+01
CR-10_OX	7	7	310	300	1.45E+01	6.90E+00	1.03E+01	2.14E+01
CR-10_OX	6.9	6.8	300	300	1.00E+01	2.20E+00	8.69E+00	1.22E+01
CR-10_RE	7.2	7.4	-210	-200	1.12E+04	8.90E+02	1.00E+04	1.21E+04
CR-10_RE	7.4	7.2	-210	-200	1.17E+04	5.60E+02	1.11E+04	1.21E+04
CR-10_RE	7.2	7.4	-200	-200	8.78E+03	2.12E+03	7.01E+03	1.09E+04
CR-10NF_RE	9.2	9.3	-210	-200	9.29E+03	1.39E+03	7.90E+03	1.02E+04
CR-10NF_RE	9.3	9.2	-200	-210	1.02E+04	1.30E+03	8.94E+03	1.15E+04
CR-10NF_RE	9.1	9.2	-210	-200	8.11E+03	2.36E+03	5.75E+03	1.00E+04
CR-0_OX	7.2	7.3	300	300	9.92E+00	4.17E+00	5.75E+00	1.36E+01
CR-0_OX	7.3	7.4	300	300	1.03E+01	3.90E+00	6.36E+00	1.35E+01
CR-0_OX	7.4	7.1	310	300	1.55E+01	9.00E-01	1.48E+01	1.64E+01
CR-0_RE	7.8	7.7	-210	-200	1.18E+04	1.50E+02	1.20E+04	1.17E+04
CR-0_RE	7.6	7.8	-200	-200	1.27E+04	3.97E+03	9.97E+03	1.67E+04
CR-0_RE	7.8	7.8	-210	-200	1.16E+04	1.78E+03	9.82E+03	1.33E+04

Table A-28: K_d measurement data of Tc on IG_BH03_SO002 (biotite granodiorite tonalite)

Solution Ox/Re	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
CR-10_OX	6.7	6.8	330	300	1.24E+01	1.50E+00	1.13E+01	1.39E+01
CR-10_OX	6.8	6.8	310	310	1.32E+01	6.00E-01	1.27E+01	1.38E+01
CR-10_OX	6.6	6.9	300	310	1.03E+01	2.87E+00	7.43E+00	1.31E+01
CR-10_RE	7.1	7.4	-210	-200	1.17E+04	1.79E+03	1.05E+04	1.35E+04
CR-10_RE	7.3	7.3	-210	-200	1.18E+04	1.05E+03	1.11E+04	1.29E+04
CR-10_RE	7.4	7.4	-200	-200	1.06E+04	8.10E+02	9.94E+03	1.14E+04
CR-10NF_RE	9.2	9.2	-210	-200	1.04E+04	2.87E+03	7.53E+03	1.28E+04
CR-10NF_RE	9.1	9.4	-210	-200	1.11E+04	9.50E+02	1.05E+04	1.21E+04
CR-10NF_RE	9.3	9.2	-210	-200	1.08E+04	2.05E+03	8.75E+03	1.29E+04
CR-0_OX	7.2	7.2	310	300	1.30E+01	4.80E+00	8.31E+00	1.78E+01
CR-0_OX	7.3	7.3	300	300	1.62E+01	6.30E+00	1.25E+01	2.25E+01
CR-0_OX	7.2	7.1	310	300	1.09E+01	2.30E+00	8.60E+00	1.22E+01
CR-0_RE	7.6	7.8	-210	-200	8.91E+03	2.34E+03	6.62E+03	1.13E+04
CR-0_RE	7.8	7.7	-200	-210	9.07E+03	1.79E+03	7.28E+03	1.06E+04
CR-0_RE	7.8	7.8	-200	-200	1.18E+04	1.41E+03	1.04E+04	1.31E+04

Table A-29: K_d measurement data of Tc on IG_BH03_SO005 (amphibolite)

Solution Ox/Re	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
CR-10_OX	6.6	7	310	300	3.33E+01	1.24E+01	2.09E+01	4.13E+01
CR-10_OX	6.7	6.8	300	300	4.76E+01	3.64E+01	2.74E+01	8.40E+01
CR-10_OX	6.5	6.8	320	300	3.46E+01	7.40E+00	2.72E+01	4.13E+01
CR-10_RE	7.2	7.3	-210	-200	2.46E+04	3.47E+03	2.12E+04	2.81E+04
CR-10_RE	7.2	7.2	-200	-200	1.92E+04	5.18E+03	1.48E+04	2.44E+04
CR-10_RE	7.4	7.1	-210	-200	2.23E+04	7.76E+03	1.69E+04	3.01E+04
CR-10NF_RE	9.1	9.4	-200	-200	2.23E+04	2.74E+03	2.00E+04	2.50E+04
CR-10NF_RE	9.2	9.3	-190	-200	1.94E+04	2.15E+03	1.73E+04	2.07E+04
CR-10NF_RE	9	9.4	-210	-200	2.31E+04	6.92E+03	1.62E+04	2.77E+04
CR-0_OX	7.2	7.3	310	300	3.16E+01	1.76E+01	1.40E+01	4.26E+01
CR-0_OX	7.1	7.1	300	300	2.68E+01	1.01E+01	1.67E+01	3.32E+01
CR-0_OX	7.2	7.1	310	310	2.77E+01	9.10E+00	2.19E+01	3.68E+01
CR-0_RE	7.6	7.9	-210	-200	2.48E+04	2.44E+03	2.24E+04	2.63E+04
CR-0_RE	7.8	7.9	-220	-210	2.05E+04	5.87E+03	1.46E+04	2.57E+04
CR-0_RE	7.9	7.7	-220	-200	2.45E+04	1.11E+03	2.34E+04	2.56E+04

Table A-30: K_d measurement data of Tc on IG_BH05_SO001 (diabase dyke)

Solution Ox/Re	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
CR-10_OX	6.8	6.8	310	300	7.04E+00	1.48E+00	6.19E+00	8.52E+00
CR-10_OX	7	6.7	300	300	7.74E+00	1.22E+00	6.53E+00	8.96E+00
CR-10_OX	7.1	6.6	300	310	6.70E+00	5.40E-01	6.16E+00	7.24E+00
CR-10_RE	7	7.4	-200	-200	1.00E+04	6.30E+02	9.50E+03	1.07E+04
CR-10_RE	7.2	7.3	-210	-200	1.00E+04	8.30E+02	9.23E+03	1.09E+04
CR-10_RE	7.3	7.3	-210	-200	1.07E+04	1.03E+03	9.73E+03	1.18E+04
CR-10NF_RE	9.3	9.2	-210	-200	1.02E+04	9.86E+02	9.40E+03	1.12E+04
CR-10NF_RE	9.4	9.4	-220	-210	1.10E+04	7.47E+02	1.03E+04	1.17E+04
CR-10NF_RE	9.4	9.3	-220	-200	1.11E+04	5.89E+02	1.05E+04	1.15E+04
CR-0_OX	7.4	7.3	300	300	8.38E+00	7.57E-01	7.70E+00	9.14E+00
CR-0_OX	7.5	7.4	300	300	7.06E+00	1.46E+00	6.26E+00	8.52E+00
CR-0_OX	7.5	7.4	300	300	7.41E+00	1.37E+00	6.03E+00	8.56E+00
CR-0_RE	7.6	7.5	-200	-200	1.10E+05	6.50E+02	1.04E+04	1.16E+04
CR-0_RE	7.7	7.7	-200	-200	1.12E+04	5.34E+02	1.07E+04	1.16E+04
CR-0_RE	7.9	7.8	-220	-210	9.50E+03	3.47E+02	9.25E+03	9.92E+03

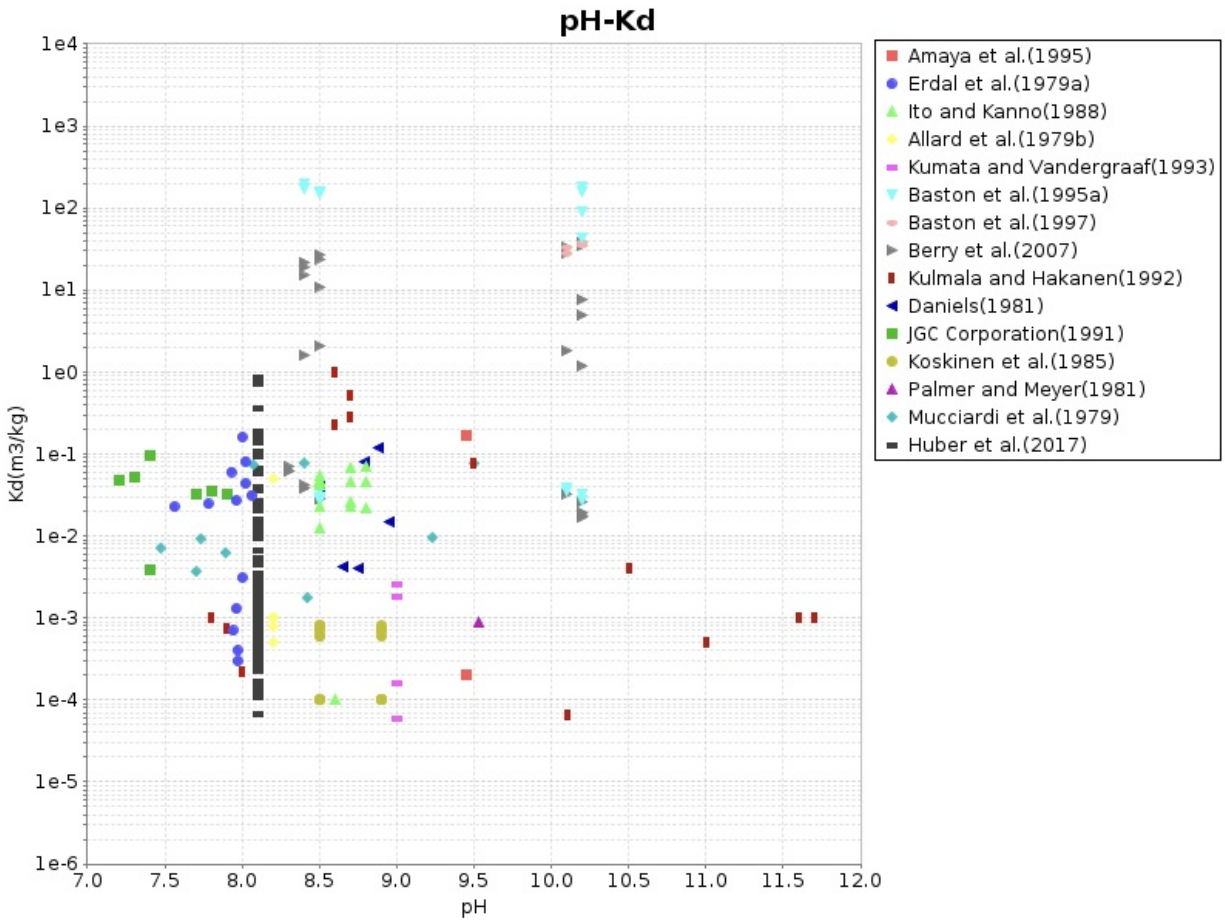


Figure A-3: K_d of Tc on granite compiled in JAEA database (pH dependence)

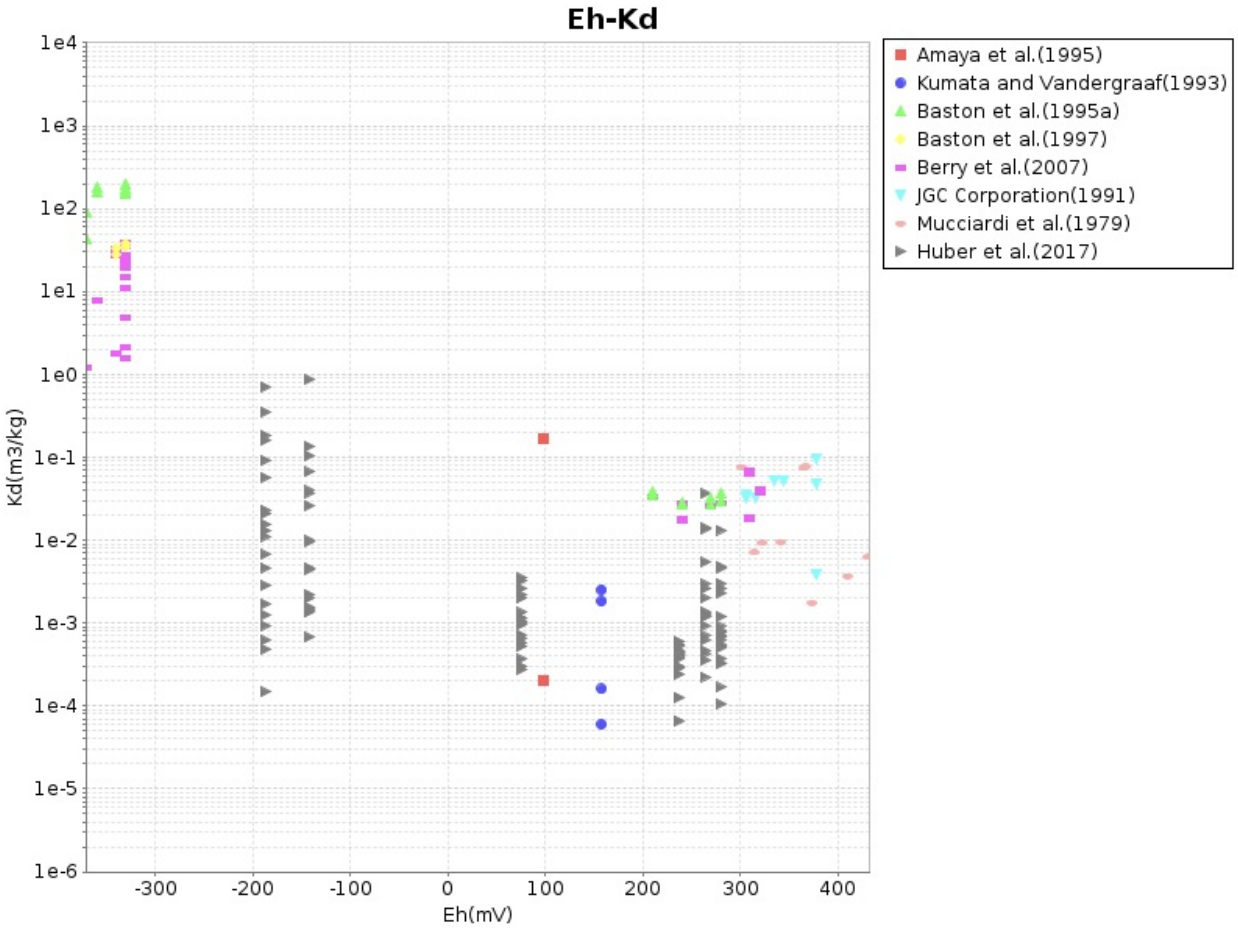


Figure A-4: K_d of Tc on granite compiled in JAEA database (Eh dependence)

Table A-31: Sorption kinetics data of Np on IG_BH01_SO001 (biotite granodiorite tonalite) in CR-10 (Oxidizing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	6.8	6.8	350	330	3.63E+00	1.80E+00	1.83E+00	5.06E+00
2	6.7	7	330	320	8.41E+00	1.37E+00	7.04E+00	9.57E+00
3	6.8	7	340	300	8.69E+00	1.65E+00	9.23E+00	9.80E+00
7	6.5	6.9	350	330	9.00E+00	1.70E+00	7.89E+00	1.07E+01
14	6.8	7.1	340	320	7.97E+00	1.64E+00	6.84E+00	9.61E+00
21	6.9	6.8	350	320	9.70E+00	1.18E+00	8.98E+00	1.09E+01

Table A-32: Sorption kinetics data of Np on IG_BH01_SO001 (biotite granodiorite tonalite) in CR-10 (Reducing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	6.8	7.2	-200	-200	1.94E+03	1.92E+02	1.75E+03	2.07E+03
2	7.2	7.3	-190	-210	7.12E+03	3.65E+02	6.75E+03	7.40E+03
3	7.2	7.2	-200	-210	7.64E+03	1.26E+03	6.69E+03	8.90E+03
7	7.1	7.3	-220	-210	7.52E+03	1.10E+03	6.46E+03	8.62E+03
14	7.3	7.3	-200	-200	7.17E+03	1.37E+03	5.80E+03	7.85E+03
21	7.1	7.2	-210	-210	8.12E+03	3.10E+02	7.93E+03	8.43E+03

Table A-33: Sorption kinetics data of Np on IG_BH01_SO001 (biotite granodiorite tonalite) in CR-10NF (Reducing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	9.1	9.2	-210	-210	3.40E+03	3.81E+02	3.12E+03	3.78E+03
2	9.2	8.9	-200	-200	7.19E+03	4.98E+02	6.69E+03	7.47E+03
3	9	9.1	-200	-200	7.69E+03	6.30E+02	7.06E+03	8.09E+03
7	9.1	9.2	-210	-200	8.19E+03	5.73E+02	7.62E+03	8.62E+03
14	9	9.3	-220	-200	8.51E+03	1.51E+03	7.00E+03	9.91E+03
21	8.9	9.2	-200	-210	5.76E+03	8.69E+02	5.29E+03	6.63E+03

Table A-34: Sorption kinetics data of Np on IG_BH01_SO001 (biotite granodiorite tonalite) in CR-0 (Oxidizing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	7.7	7.5	330	330	1.85E+00	5.40E-01	1.52E+00	2.39E+00
2	7.8	7.6	300	300	9.55E+00	1.30E+00	8.25E+00	1.05E+01
3	7.5	7.7	310	310	1.04E+01	4.00E-01	1.00E+01	1.07E+01
7	7.7	7.6	300	310	1.26E+01	1.97E+00	1.10E+01	1.46E+01
14	7.8	7.5	300	300	1.02E+01	1.77E+00	8.42E+00	1.11E+01
21	7.8	7.6	320	320	9.94E+00	1.28E+00	8.66E+00	1.11E+01

Table A-35: Sorption kinetics data of Np on IG_BH01_SO001 (biotite granodiorite tonalite) in CR-0 (Reducing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	7.8	7.7	-200	-200	3.50E+03	7.11E+02	3.08E+03	4.21E+03
2	7.8	7.8	-210	-210	6.99E+03	1.53E+03	6.04E+03	8.52E+03
3	7.6	7.7	-220	-200	7.33E+03	5.95E+02	6.87E+03	7.93E+03
7	7.7	7.8	-210	-200	8.64E+03	7.95E+02	7.85E+03	9.18E+03
14	7.8	7.8	-200	-200	7.41E+03	1.11E+03	6.58E+03	8.52E+03
21	7.9	7.7	-200	-200	8.02E+03	3.98E+02	7.62E+03	8.35E+03

Table A-36: Sorption kinetics data of Np on IG_BH05_SO001 (diabase dyke) in CR-10 (Oxidizing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	6.8	6.8	310	300	3.99E+00	2.27E+00	1.83E+00	6.26E+00
2	6.9	7	300	300	8.52E+00	1.43E+00	7.09E+00	9.42E+00
3	6.8	6.7	300	300	8.80E+00	1.25E+00	7.54E+00	9.80E+00
7	6.7	6.9	310	300	9.07E+00	1.94E+00	7.86E+00	1.10E+01
14	6.8	6.8	300	300	8.07E+00	1.34E+00	6.95E+00	9.42E+00
21	6.9	7.1	300	300	9.73E+00	1.19E+00	9.05E+00	1.09E+01

Table A-37: Sorption kinetics data of Np on IG_BH05_SO001 (diabase dyke) in CR-10 (Reducing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	7.2	7.3	-200	-200	4.90E+02	8.95E+01	3.55E+02	5.80E+02
2	7.2	7.4	-200	-200	2.92E+03	4.95E+02	2.43E+03	3.24E+03
3	7.3	7.3	-210	-200	3.46E+03	6.28E+02	2.83E+03	4.00E+03
7	7.3	7.2	-200	-200	3.14E+03	8.08E+02	2.72E+03	3.95E+03
14	7.3	7.1	-200	-200	2.97E+03	5.83E+02	2.39E+03	3.29E+03
21	7.3	7.4	-200	-200	3.53E+03	1.81E+02	3.35E+03	3.65E+03

Table A-38: Sorption kinetics data of Np on IG_BH05_SO001 (diabase dyke) in CR-10NF (Reducing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	9.2	9.4	-210	-200	1.25E+03	1.38E+02	1.15E+03	1.39E+03
2	9.3	9.2	-210	-200	3.11E+03	2.61E+02	2.85E+03	3.29E+03
3	9.2	9.4	-200	-200	3.29E+03	2.85E+02	3.00E+03	3.55E+03
7	9.1	9.3	-210	-210	3.67E+03	1.10E+02	3.59E+03	3.79E+03
14	9.2	9.2	-200	-200	3.72E+03	7.99E+02	2.92E+03	4.29E+03
21	9.3	9.3	-200	-200	2.87E+03	5.44E+02	2.32E+03	3.29E+03

Table A-39: Sorption kinetics data of Np on IG_BH05_SO001 (diabase dyke) in CR-0 (Oxidizing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	7.3	7.1	310	300	1.43E+00	1.17E+00	2.56E-01	2.12E+00
2	7.2	7.3	300	300	9.62E+00	7.55E-01	8.87E+00	1.00E+01
3	7.4	7.2	310	310	1.04E+01	3.94E-01	9.61E+00	1.07E+01
7	7.2	7.4	310	300	1.27E+01	1.83E+00	1.17E+01	1.45E+01
14	7.3	7.5	300	310	1.06E+01	7.26E-01	9.92E+00	1.11E+01
21	7.2	7.3	300	300	1.08E+01	5.98E-01	1.02E+01	1.14E+01

Table A-40: Sorption kinetics data of Np on IG_BH05_SO001 (diabase dyke) in CR-0 (Reducing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	7.8	7.7	-210	-200	1.23E+03	3.23E+02	1.02E+03	1.55E+03
2	7.6	7.6	-220	-200	2.91E+03	6.31E+02	2.51E+03	3.55E+03
3	7.8	7.9	-210	-200	3.12E+03	1.99E+02	2.92E+03	3.29E+03
7	7.6	7.8	-210	-200	3.78E+03	4.48E+02	3.33E+03	4.05E+03
14	7.7	7.4	-200	-200	3.11E+03	4.38E+02	2.76E+03	3.55E+03
21	7.6	7.6	-200	-200	3.48E+03	1.52E+02	3.33E+03	3.61E+03

Table A-41: K_d measurement data of Np on IG_BH01_SO001 (biotite granodiorite tonalite)

Solution Ox/Re	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
CR-10_OX	6.9	6.7	320	320	1.24E+01	9.10E-01	1.18E+01	1.33E+01
CR-10_RE	6.8	7.2	-200	-200	8.61E+03	1.90E+03	7.47E+03	1.05E+04
CR-10NF_RE	9.1	9.3	-210	-220	8.21E+03	4.02E+02	7.85E+03	8.62E+03
CR-0_OX	7.6	7.6	310	320	9.31E+00	1.80E+00	7.51E+00	1.11E+01
CR-0_RE	7.8	7.4	-210	-200	8.56E+03	2.09E+03	7.40E+03	1.06E+04

Table A-42: K_d measurement data of Np on IG_BH01_SO014 biotite granodiorite tonalite)

Solution Ox/Re	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
CR-10_OX	7.1	7.3	320	300	8.99E+00	1.10E+00	7.89E+00	9.76E+00
CR-10_RE	7	7.3	-200	-210	8.67E+03	9.78E+02	7.70E+03	9.20E+03
CR-10NF_RE	9	9.1	-200	-210	8.25E+03	1.46E+03	6.87E+03	9.71E+03
CR-0_OX	7.4	7.4	300	300	1.14E+01	2.00E-01	1.12E+01	1.16E+01
CR-0_RE	7.4	7.6	-210	-220	7.90E+03	5.63E+02	7.33E+03	8.35E+03

Table A-43: K_d measurement data of Np on IG_BH03_SO002 biotite granodiorite tonalite)

Solution Ox/Re	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
CR-10_OX	6.8	7	300	290	9.20E+00	1.40E+00	7.80E+00	1.01E+01
CR-10_OX	7.3	7.4	300	300	8.30E+00	1.70E+00	7.40E+00	1.00E+01
CR-10_OX	7.3	7.1	310	310	8.70E+00	3.40E+00	5.40E+00	1.20E+01
CR-10_RE	7.1	6.9	-200	-180	8.33E+03	5.63E+02	7.77E+03	8.71E+03
CR-10_RE	7.5	6.8	-200	-190	8.18E+03	1.12E+03	7.07E+03	9.13E+03
CR-10_RE	6.9	7.2	-210	-200	7.31E+03	9.30E+01	7.26E+03	7.40E+03
CR-10NF_RE	8.8	9.2	-200	-210	8.09E+03	6.10E+02	7.48E+03	8.43E+03
CR-10NF_RE	8.9	9.2	-200	-200	7.80E+03	1.28E+03	6.52E+03	8.62E+03
CR-10NF_RE	8.5	8.8	-200	-190	8.79E+03	7.81E+02	8.01E+03	9.35E+03
CR-0_OX	7.5	7.7	300	290	1.06E+01	1.40E+00	9.20E+00	1.17E+01
CR-0_OX	7.6	7.5	310	300	9.30E+00	2.40E+00	6.90E+00	1.11E+01
CR-0_OX	7.8	7.5	300	300	1.11E+01	2.00E+00	9.30E+00	1.31E+01
CR-0_RE	7.6	7.6	-200	-190	7.88E+03	9.40E+02	6.94E+03	8.43E+03
CR-0_RE	7.8	7.5	-210	-200	7.92E+03	5.14E+02	7.48E+03	8.43E+03
CR-0_RE	7.8	7.8	-200	-200	8.08E+03	9.79E+02	7.33E+03	9.06E+03

Table A-44: K_d measurement data of Np on IG_BH03_SO005 (amphibolite)

Solution Ox/Re	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
CR-10_OX	6.9	7.2	320	300	3.54E+01	2.00E+00	3.35E+01	3.67E+01
CR-10_OX	7.2	7.1	300	300	3.18E+01	2.70E+00	2.91E+01	3.43E+01
CR-10_OX	7.4	7.3	300	290	3.21E+01	5.30E+00	2.72E+01	3.74E+01
CR-10_RE	7.3	7.2	-200	-190	2.68E+04	1.58E+03	2.58E+04	2.83E+04
CR-10_RE	7.1	6.8	-200	-190	1.79E+04	1.72E+03	1.70E+04	1.97E+04
CR-10_RE	7	7.3	-200	-190	1.95E+04	1.47E+03	1.80E+04	2.07E+04
CR-10NF_RE	9	9.3	-200	-200	1.84E+04	1.30E+03	1.68E+04	1.97E+04
CR-10NF_RE	8.8	8.9	-190	-190	1.91E+04	1.05E+03	1.80E+04	1.98E+04
CR-10NF_RE	9.1	8.8	-210	-190	1.65E+04	2.95E+03	1.40E+04	1.95E+04
CR-0_OX	7.3	7.7	300	310	3.67E+01	7.00E+00	3.26E+01	4.38E+01
CR-0_OX	7.4	7.4	310	300	3.54E+01	4.60E+00	3.08E+01	3.90E+01
CR-0_OX	7.7	7.2	300	300	3.23E+01	1.20E+00	3.26E+01	3.33E+01
CR-0_RE	7.8	7.5	-200	-190	1.92E+04	3.59E+02	1.86E+04	1.98E+04
CR-0_RE	7.6	7.6	-200	-190	1.91E+04	4.48E+03	1.46E+04	2.26E+04
CR-0_RE	7.5	7.8	-200	-200	1.93E+04	1.08E+03	1.83E+04	2.02E+04

Table A-45: K_d measurement data of Np on IG_BH01_SO001 biotite granodiorite tonalite)

Solution Ox/Re	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
CR-10_OX	6.8	6.7	310	310	8.29E+00	8.27E-01	7.54E+00	9.12E+00
CR-10_OX	6.9	7	310	300	8.91E+00	1.25E+00	7.67E+00	9.88E+00
CR-10_OX	6.6	6.8	300	310	8.50E+00	8.80E-01	7.70E+00	9.31E+00
CR-10_RE	7.3	7.4	-200	-200	2.74E+03	5.10E+01	2.69E+03	2.77E+03
CR-10_RE	7.2	7.2	-210	-200	3.31E+03	6.20E+02	2.72E+03	3.93E+03
CR-10_RE	7.4	7.3	-200	-200	3.08E+03	4.24E+02	2.70E+03	3.51E+03
CR-10NF_RE	9.3	9.1	-220	-210	2.94E+03	2.65E+02	2.72E+03	3.20E+03
CR-10NF_RE	9.2	9.1	-200	-200	3.20E+03	6.29E+02	2.57E+03	3.74E+03
CR-10NF_RE	9.4	9.2	-200	-200	3.06E+03	2.55E+02	2.80E+03	3.22E+03
CR-0_OX	7.4	7.3	320	300	8.77E+00	1.04E+00	7.73E+00	9.65E+00
CR-0_OX	7.4	7.4	300	310	8.67E+00	6.70E-01	8.02E+00	9.34E+00
CR-0_OX	7.3	7.3	300	300	7.83E+00	3.84E-01	7.45E+00	8.21E+00
CR-0_RE	7.5	7.6	-200	-200	3.49E+03	3.94E+02	3.10E+03	3.85E+03
CR-0_RE	7.8	7.7	-210	-210	2.75E+03	1.72E+02	2.60E+03	2.92E+03
CR-0_RE	7.7	7.6	-200	-200	3.30E+03	4.82E+02	2.92E+03	3.79E+03

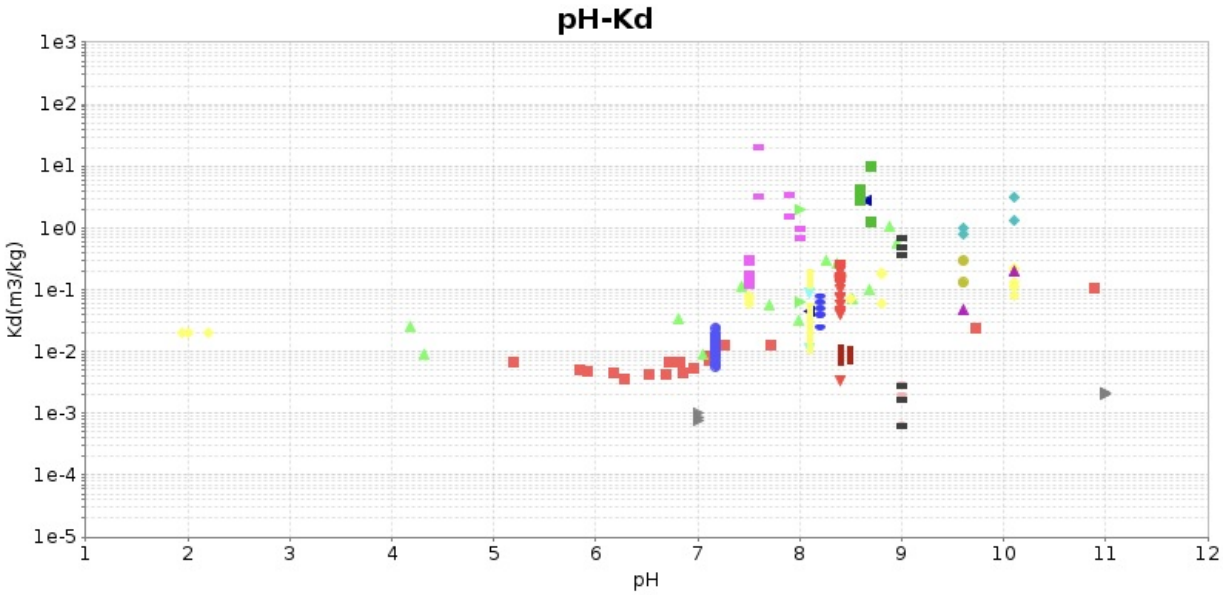


Figure A-5: K_d of Np on granite compiled in JAEA database (pH dependence)

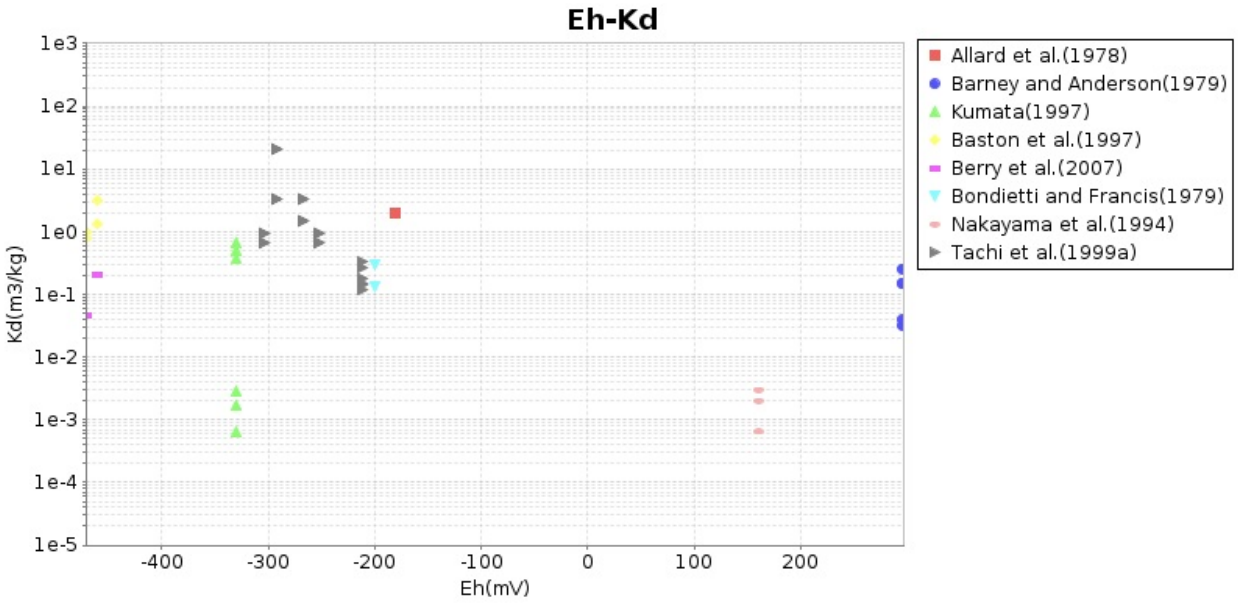


Figure A-6: K_d of Np on granite compiled in JAEA database (Eh dependence)

Table A-46: Sorption kinetics data of U on IG_BH01_SO014 (biotite granodiorite tonalite) in CR-10 (Oxidizing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	6.8	6.8	300	300	5.50E+01	6.10E+00	4.89E+01	5.98E+01
2	6.8	7	300	300	6.55E+01	2.03E+01	4.52E+01	8.37E+01
3	6.8	6.8	300	300	9.51E+01	5.60E+00	8.99E+01	1.01E+02
7	6.8	6.9	300	310	9.64E+01	2.60E+00	9.38E+01	9.85E+01
14	6.8	6.8	300	310	9.89E+01	2.70E+00	9.75E+01	1.02E+02
21	6.8	6.9	300	310	9.89E+01	1.70E+00	9.72E+01	1.01E+02

Table A-47: Sorption kinetics data of U on IG_BH01_SO014 (biotite granodiorite tonalite) in CR-10 (Reducing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	7.2	7.2	-210	-200	3.38E+03	1.21E+03	2.17E+03	4.04E+03
2	7.2	7.3	-210	-210	5.14E+03	3.04E+03	2.89E+03	8.18E+03
3	7.2	7.2	-210	-200	9.51E+03	9.09E+02	8.92E+03	1.04E+04
7	7.2	7.4	-210	-210	9.55E+03	1.03E+03	8.51E+03	1.03E+04
14	7.2	7.2	-210	-210	9.40E+03	1.48E+03	7.92E+03	1.06E+05
21	7.2	7.3	-210	-210	9.62E+03	6.56E+02	8.96E+03	1.03E+04

Table A-48: Sorption kinetics data of U on IG_BH01_SO014 (biotite granodiorite tonalite) in CR-10NF (Reducing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	8.9	8.9	-210	-210	3.61E+03	1.36E+03	2.25E+03	4.43E+03
2	8.9	9.1	-210	-210	5.94E+03	1.52E+03	4.97E+03	7.46E+03
3	8.9	9.2	-210	-200	9.68E+03	5.80E+02	9.11E+03	1.03E+04
7	8.9	9.2	-210	-210	1.01E+04	3.29E+02	9.86E+03	1.04E+04
14	8.9	9.2	-210	-200	9.13E+03	9.22E+02	8.44E+03	1.00E+04
21	8.9	9.3	-210	-210	9.31E+03	5.33E+02	8.95E+03	9.85E+03

Table A-49: Sorption kinetics data of U on IG_BH01_SO014 (biotite granodiorite tonalite) in CR-0 (Oxidizing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	7.3	7.3	300	310	5.58E+01	4.08E+00	5.17E+01	5.98E+01
2	7.3	7.4	300	300	5.98E+01	1.83E+01	4.47E+01	7.81E+01
3	7.3	7.2	300	310	9.56E+01	7.91E+00	9.05E+01	1.04E+02
7	7.3	7.2	300	310	9.73E+01	8.91E+00	8.84E+01	1.06E+02
14	7.3	7.2	300	320	9.68E+01	6.62E+00	9.02E+01	1.03E+02
21	7.3	7.3	300	310	9.42E+01	1.12E+01	8.30E+01	1.01E+02

Table A-50: Sorption kinetics data of U on IG_BH01_SO014 (biotite granodiorite tonalite) in CR-0 (Reducing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	7.8	7.8	-210	-200	4.01E+03	1.07E+03	2.94E+03	4.75E+03
2	7.8	7.9	-210	-210	5.28E+03	2.38E+03	5.12E+03	7.67E+03
3	7.8	7.8	-210	-210	9.48E+03	8.67E+02	9.02E+03	1.04E+04
7	7.8	7.7	-210	-200	9.68E+03	9.63E+02	8.91E+03	1.06E+04
14	7.8	7.8	-210	-210	9.75E+03	5.29E+02	9.02E+03	1.03E+04
21	7.8	7.8	-210	-210	9.58E+03	7.30E+02	8.51E+03	1.03E+04

Table A-51: Sorption kinetics data of U on IG_BH03_SO005 (amphibolite) in CR-10 (Oxidizing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	6.7	6.6	310	310	7.29E+01	8.69E+00	6.60E+01	8.16E+01
2	6.8	6.7	310	300	1.09E+02	1.73E+01	9.80E+01	1.26E+02
3	6.7	6.8	300	320	1.82E+02	4.10E+01	1.47E+02	2.23E+02
7	6.8	6.8	310	320	2.16E+02	2.32E+01	1.87E+02	2.39E+02
14	6.8	6.9	300	310	2.15E+02	2.61E+01	1.95E+02	2.41E+02
21	6.9	6.7	310	310	1.97E+02	2.16E+01	1.82E+02	2.19E+02

Table A-52: Sorption kinetics data of U on IG_BH03_SO005 (amphibolite) in CR-10 (Reducing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	7.2	7.1	-220	-210	4.18E+03	9.32E+02	3.48E+03	5.12E+03
2	7.3	7.3	-210	-200	9.50E+03	7.75E+02	8.89E+03	1.03E+04
3	7.2	7.3	-200	-200	1.12E+04	8.44E+02	9.86E+03	1.21E+04
7	7.3	7.4	-210	-210	1.77E+04	4.60E+03	1.52E+04	2.23E+04
14	7.4	7.3	-200	-210	1.97E+04	2.87E+03	1.66E+04	2.26E+04
21	7.2	7.3	-200	-210	2.01E+04	1.56E+03	1.90E+04	2.17E+04

Table A-53: Sorption kinetics data of U on IG_BH03_SO005 (amphibolite) in CR-10NF (Reducing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	9.4	9.3	-210	-200	3.10E+03	5.80E+02	2.68E+03	3.68E+03
2	9.5	9.4	-200	-210	7.73E+03	4.59E+02	7.20E+03	8.19E+03
3	9.4	9.2	-210	-210	1.28E+04	2.46E+03	9.89E+03	1.53E+04
7	9.3	9.5	-210	-200	1.92E+04	4.73E+03	1.57E+04	2.39E+04
14	9.2	9.3	-200	-200	1.87E+04	3.26E+03	1.50E+04	2.19E+04
21	9.4	9.4	-210	-210	2.19E+04	2.13E+03	1.82E+04	2.41E+04

Table A-54: Sorption kinetics data of U on IG_BH03_SO005 (amphibolite) in CR-0 (Oxidizing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	7.3	7.4	300	300	5.85E+01	7.17E+00	5.10E+01	6.56E+01
2	7.4	7.5	310	300	1.06E+02	1.50E+01	9.09E+01	1.21E+02
3	7.3	7.4	300	300	1.44E+02	1.60E+01	1.31E+02	1.60E+02
7	7.2	7.1	310	310	2.04E+02	2.49E+01	1.88E+02	2.29E+02
14	7.2	7.3	310	310	1.80E+02	4.78E+01	1.54E+02	2.28E+02
21	7.3	7.3	300	300	1.68E+02	2.12E+01	1.49E+02	1.90E+02

Table A-55: Sorption kinetics data of U on IG_BH03_SO005 (amphibolite) in CR-0 (Reducing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	7.7	7.5	-200	-210	3.59E+03	4.92E+02	3.10E+03	4.09E+03
2	7.6	7.7	-210	-200	7.46E+03	1.36E+03	6.59E+03	8.82E+03
3	7.8	7.8	-210	-200	1.45E+04	3.84E+03	1.17E+04	1.83E+04
7	7.7	7.9	-200	-210	1.91E+04	1.45E+03	1.82E+04	2.06E+04
14	7.6	7.7	-210	-200	1.96E+04	3.07E+03	1.66E+04	2.27E+04
21	7.8	7.7	-210	-200	1.86E+04	4.33E+03	1.63E+04	2.29E+04

Table A-56: Sorption kinetics data of U on IG_BH05_SO001 (diabase dyke) in CR-10 (Oxidizing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	6.8	6.8	310	300	5.29E+01	4.35E+00	4.77E+01	5.72E+01
2	6.9	6.8	310	310	5.94E+01	2.01E+01	4.47E+01	7.94E+01
3	7.1	6.6	300	300	9.69E+01	8.59	8.82E+01	1.06E+02
7	6.7	6.8	310	310	9.16E+01	8.18E+00	8.48E+01	9.98E+01
14	6.6	6.9	300	300	9.75E+01	5.98E+00	8.99E+01	1.04E+02
21	6.7	6.8	310	300	9.75E+01	5.37E+00	9.15E+01	1.03E+02

Table A-57: Sorption kinetics data of U on IG_BH05_SO001 (diabase dyke) in CR-10 (Reducing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	7.2	7.3	-210	-200	4.23E+03	8.28E+02	3.59E+03	4.04E+03
2	7.2	7.2	-220	-200	4.45E+03	7.20E+02	3.82E+03	5.17E+03
3	7.3	7.4	-210	-210	1.02E+04	9.80E+02	8.84E+03	1.12E+04
7	7.2	7.3	-210	-200	9.36E+03	1.20E+03	7.90E+03	1.06E+04
14	7.1	7.2	-200	-210	9.56E+03	1.19E+03	8.78E+03	1.08E+04
21	7.4	7.3	-210	-200	9.01E+03	3.51E+02	8.48E+03	9.36E+03

Table A-58: Sorption kinetics data of U on IG_BH05_SO001 (diabase dyke) in CR-10NF (Reducing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	9.2	9	-200	-210	3.24E+03	1.09E+03	2.43E+03	4.33E+03
2	9	9.1	-200	-200	5.64E+03	9.45E+02	5.05E+03	6.59E+03
3	9.1	9.3	-200	-210	9.71E+03	5.63E+02	9.14E+03	1.03E+04
7	9.4	9.1	-210	-200	9.14E+03	1.42E+03	8.08E+03	1.06E+04
14	9.2	9.2	-210	-210	9.37E+03	7.03E+02	8.48E+03	1.01E+04
21	9.4	9.5	-220	-210	9.27E+03	9.75E+02	8.06E+03	1.02E+04

Table A-59: Sorption kinetics data of U on IG_BH05_SO001 (diabase dyke) in CR-0 (Oxidizing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	7.3	7.3	310	300	4.43E+01	5.69E+00	3.82E+01	5.00E+01
2	7.4	7.2	300	300	5.93E+01	1.11E+01	4.39E+01	7.04E+01
3	7.2	7.1	300	300	9.02E+01	1.33E+01	7.65E+01	1.04E+02
7	7.2	7.4	310	310	8.98E+01	1.58E+01	7.94E+01	1.06E+02
14	7.1	7.3	310	300	9.27E+01	8.20E+00	8.21E+01	1.01E+02
21	7.4	7.3	300	300	8.83E+01	4.10E+00	8.30E+01	9.24E+01

Table A-60: Sorption kinetics data of U on IG_BH05_SO001 (diabase dyke) in CR-0 (Reducing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	7.6	7.5	-210	-210	3.46E+03	4.50E+02	2.86E+03	3.91E+03
2	7.8	7.6	-210	-200	5.46E+03	1.63E+03	4.32E+03	7.10E+03
3	7.7	7.9	-210	-210	9.25E+03	1.23E+03	8.36E+03	1.05E+04
7	7.8	7.6	-210	-200	8.65E+03	8.17E+02	8.07E+03	9.47E+03
14	7.8	7.7	-200	-210	9.35E+03	9.65E+02	8.59E+03	1.03E+04
21	7.9	7.8	-200	-200	9.00E+03	6.00E+02	8.39E+03	9.02E+03

Table A-61: K_d measurement data of U on IG_BH01_SO001 (biotite granodiorite tonalite)

Solution Ox/Re	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
CR-10_OX	6.5	6.7	310	300	9.74E+01	4.67E+00	9.28E+01	1.01E+02
CR-10_OX	6.6	6.6	310	300	9.88E+01	2.79E+00	9.63E+01	1.02E+02
CR-10_OX	6.5	6.6	310	300	9.74E+01	1.78E+00	9.60E+01	9.92E+01
CR-10_RE	7.4	7.2	-200	-200	9.66E+03	6.93E+02	8.97E+03	1.02E+04
CR-10_RE	7.1	7.3	-210	-200	8.84E+03	3.21E+02	8.51E+03	9.12E+03
CR-10_RE	7.3	7.2	-200	-200	9.79E+03	4.94E+02	9.40E+03	1.03E+04
CR-10NF_RE	9.5	9.3	-210	-200	9.26E+03	1.02E+02	9.19E+03	9.36E+03
CR-10NF_RE	9.3	9.3	-210	-200	9.34E+03	4.01E+02	8.95E+03	9.74E+03
CR-10NF_RE	9.1	9.4	-200	-200	9.70E+03	3.62E+02	9.34E+03	1.01E+04
CR-0_OX	7.3	7.2	300	300	9.26E+01	4.43E+00	8.89E+01	9.71E+01
CR-0_OX	7.4	7.1	300	300	9.58E+01	3.64E+00	9.33E+01	9.94E+01
CR-0_OX	7.2	7.2	320	300	9.89E+01	2.67E+00	9.63E+01	1.02E+02
CR-0_RE	7.7	7.8	-210	-200	9.41E+03	2.92E+02	9.13E+03	9.71E+03
CR-0_RE	7.8	7.8	-210	-200	9.14E+03	3.76E+02	8.86E+03	9.52E+03
CR-0_RE	7.7	7.7	-200	-200	9.37E+03	2.57E+02	9.13E+03	9.63E+03

Table A-62: K_d measurement data of U on IG_BH01_SO014 (biotite granodiorite tonalite)

Solution Ox/Re	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
CR-10_OX	6.8	6.7	300	300	9.56E+01	3.84E+00	9.17E+01	9.92E+01
CR-10_OX	6.9	6.6	300	300	8.97E+01	1.71E+00	8.79E+01	9.14E+01
CR-10_OX	6.7	6.7	300	300	9.62E+01	2.36E+00	9.46E+01	9.86E+01
CR-10_RE	7.3	7.3	-200	-200	9.97E+03	1.82E+02	9.86E+03	1.01E+04
CR-10_RE	7.2	7.3	-200	-200	9.14E+03	2.18E+02	8.94E+03	9.36E+03
CR-10_RE	7.2	7.3	-200	-200	9.41E+03	2.71E+02	9.14E+03	9.63E+03
CR-10NF_RE	8.8	9.3	-200	-200	9.07E+03	9.75E+01	8.97E+03	9.14E+03
CR-10NF_RE	8.6	9.4	-200	-200	9.29E+03	2.31E+02	9.06E+03	9.47E+03
CR-10NF_RE	8.7	9.4	-200	-200	9.38E+03	2.13E+02	9.16E+03	9.56E+03
CR-0_OX	7.5	7.2	300	300	9.30E+01	1.83E+00	9.11E+01	9.48E+01
CR-0_OX	7.1	7.2	310	300	9.07E+01	2.28E+00	8.87E+01	9.30E+01
CR-0_OX	7.3	7.1	300	300	9.35E+01	3.31E+00	9.02E+01	9.63E+01
CR-0_RE	7.7	7.7	-200	-200	9.94E+03	1.86E+02	9.75E+03	1.01E+04
CR-0_RE	7.8	7.6	-210	-200	1.00E+04	2.69E+02	9.75E+03	1.03E+04
CR-0_RE	7.9	7.8	-200	-200	9.62E+03	1.46E+02	9.47E+03	9.74E+03

Table A-63: K_d measurement data of U on IG_BH03_SO002 (biotite granodiorite tonalite)

Solution Ox/Re	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
CR-10_OX	6.6	6.8	300	300	1.00E+02	1.01E+01	9.34E+01	1.10E+02
CR-10_OX	6.8	6.7	300	300	1.05E+02	6.14E+00	1.01E+02	1.11E+02
CR-10_OX	6.9	6.6	300	300	9.39E+01	8.96E+00	8.17E+01	1.03E+02
CR-10_RE	7.4	7.4	-210	-200	1.02E+04	1.09E+03	9.49E+03	1.13E+04
CR-10_RE	7.3	7.4	-200	-200	9.45E+03	6.15E+02	8.65E+03	1.01E+04
CR-10_RE	7.2	7.2	-200	-200	8.90E+03	4.01E+02	8.55E+03	9.30E+03
CR-10NF_RE	9.3	9.4	-200	-200	9.19E+03	3.31E+02	8.86E+03	9.47E+03
CR-10NF_RE	9.1	9.3	-200	-200	9.49E+03	9.66E+02	8.92E+03	1.05E+04
CR-10NF_RE	9.5	9.3	-210	-200	9.85E+03	4.32E+02	9.57E+03	1.03E+04
CR-0_OX	7.1	7.1	300	300	1.03E+02	1.23E+01	9.02E+01	1.10E+02
CR-0_OX	7	7.2	310	300	9.13E+01	6.40E+00	8.49E+01	9.66E+01
CR-0_OX	7.3	7.2	300	300	9.01E+01	4.16E+00	8.60E+01	9.32E+01
CR-0_RE	7.9	7.8	-200	-200	1.01E+04	6.07E+02	9.65E+03	1.07E+04
CR-0_RE	8	7.7	-210	-200	8.91E+03	4.21E+02	8.49E+03	9.30E+03
CR-0_RE	7.8	7.8	-200	-200	1.03E+04	6.83E+02	9.65E+03	1.10E+04

Table A-64: K_d measurement data of U on IG_BH03_SO005 (amphibolite)

Solution Ox/Re	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
CR-10_OX	6.7	6.8	310	300	2.16E+02	4.20E+01	1.87E+02	2.58E+02
CR-10_OX	6.9	6.6	300	310	2.12E+02	4.09E+01	1.78E+02	2.52E+02
CR-10_OX	6.9	6.6	300	310	2.16E+02	2.30E+01	1.93E+02	2.38E+02
CR-10_RE	7.4	7.4	-200	-200	2.16E+04	3.65E+03	1.86E+04	2.52E+04
CR-10_RE	7.5	7.4	-200	-200	2.23E+04	1.94E+03	2.06E+04	2.43E+04
CR-10_RE	7.4	7.3	-200	-200	2.16E+04	3.28E+03	1.88E+04	2.49E+04
CR-10NF_RE	9.4	9.4	-200	-200	1.94E+04	1.53E+03	1.78E+04	2.04E+04
CR-10NF_RE	9.4	9.3	-210	-200	1.85E+04	1.65E+03	1.69E+04	2.00E+04
CR-10NF_RE	9.1	9.2	-200	-200	2.54E+04	3.61E+03	2.23E+04	2.90E+04
CR-0_OX	7.3	7.3	300	300	2.04E+02	1.46E+01	1.89E+02	2.15E+02
CR-0_OX	7.1	7.2	300	310	2.21E+02	3.36E+01	1.88E+02	2.48E+02
CR-0_OX	7.1	7.3	310	300	1.93E+02	1.51E+01	1.78E+02	2.07E+02
CR-0_RE	7.9	7.7	-200	-200	2.01E+04	1.24E+03	1.90E+04	2.13E+04
CR-0_RE	7.8	7.6	-200	-200	2.03E+04	1.92E+03	1.89E+04	2.23E+04
CR-0_RE	7.9	7.7	-200	-200	2.29E+04	1.80E+03	1.95E+04	2.47E+04

Table A-65: K_d measurement data of U on IG_BH05_SO001 (diabase dyke)

Solution Ox/Re	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
CR-10_OX	6.6	6.6	310	310	6.96E+01	4.59E+00	6.50E+01	7.35E+01
CR-10_OX	6.8	6.6	300	300	6.94E+01	3.52E+00	6.70E+01	7.29E+01
CR-10_OX	6.6	6.7	310	300	7.05E+01	4.78E+00	6.57E+01	7.42E+01
CR-10_RE	7.5	7.5	-210	-210	6.98E+03	6.07E+02	6.37E+03	7.36E+03
CR-10_RE	7.4	7.4	-200	-200	6.98E+03	5.90E+02	6.39E+03	7.50E+03
CR-10_RE	7.3	7.4	-200	-200	7.48E+03	2.01E+02	7.29E+03	7.68E+03
CR-10NF_RE	9.5	9.4	-210	-200	6.99E+03	4.39E+02	6.63E+03	7.42E+03
CR-10NF_RE	9.5	9.3	-200	-200	7.45E+03	3.86E+02	7.06E+03	7.70E+03
CR-10NF_RE	9.3	9.4	-200	-200	7.35E+03	4.19E+02	6.93E+03	7.63E+03
CR-0_OX	7.4	7.1	300	300	6.71E+01	1.74E+00	6.57E+01	6.88E+01
CR-0_OX	7.3	7.2	300	300	7.06E+01	4.27E+00	6.65E+01	7.48E+01
CR-0_OX	7.3	7.2	300	300	6.89E+01	4.69E+00	6.55E+01	7.36E+01
CR-0_RE	7.8	7.7	-210	-200	7.10E+03	5.59E+02	6.59E+03	7.66E+03
CR-0_RE	7.7	7.8	-210	-200	6.96E+03	5.06E+02	6.46E+03	7.47E+03
CR-0_RE	7.8	7.7	-200	-200	6.76E+03	2.77E+02	6.52E+03	7.03E+03

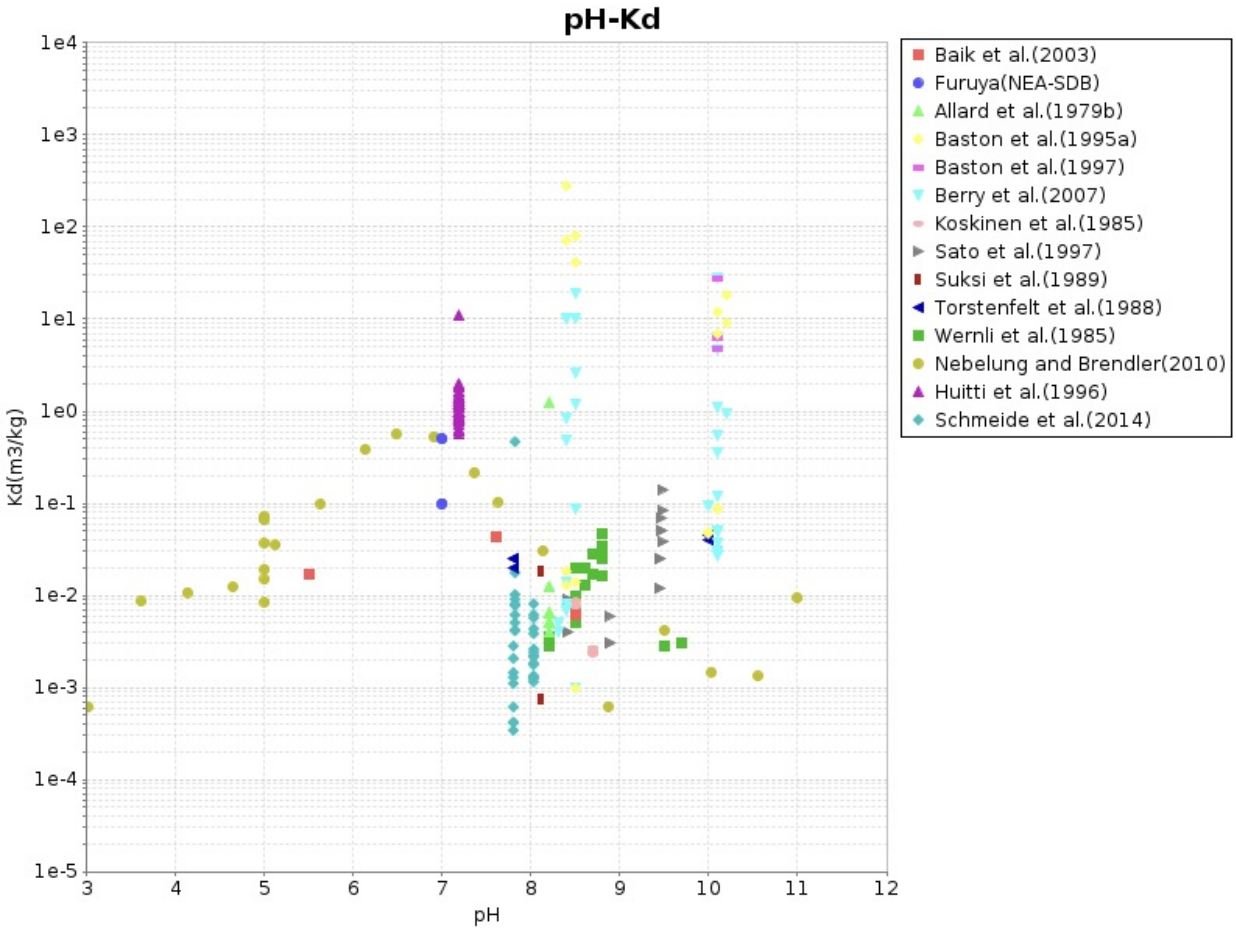


Figure A-7: K_d of U on granite compiled in JAEA database (pH dependence)

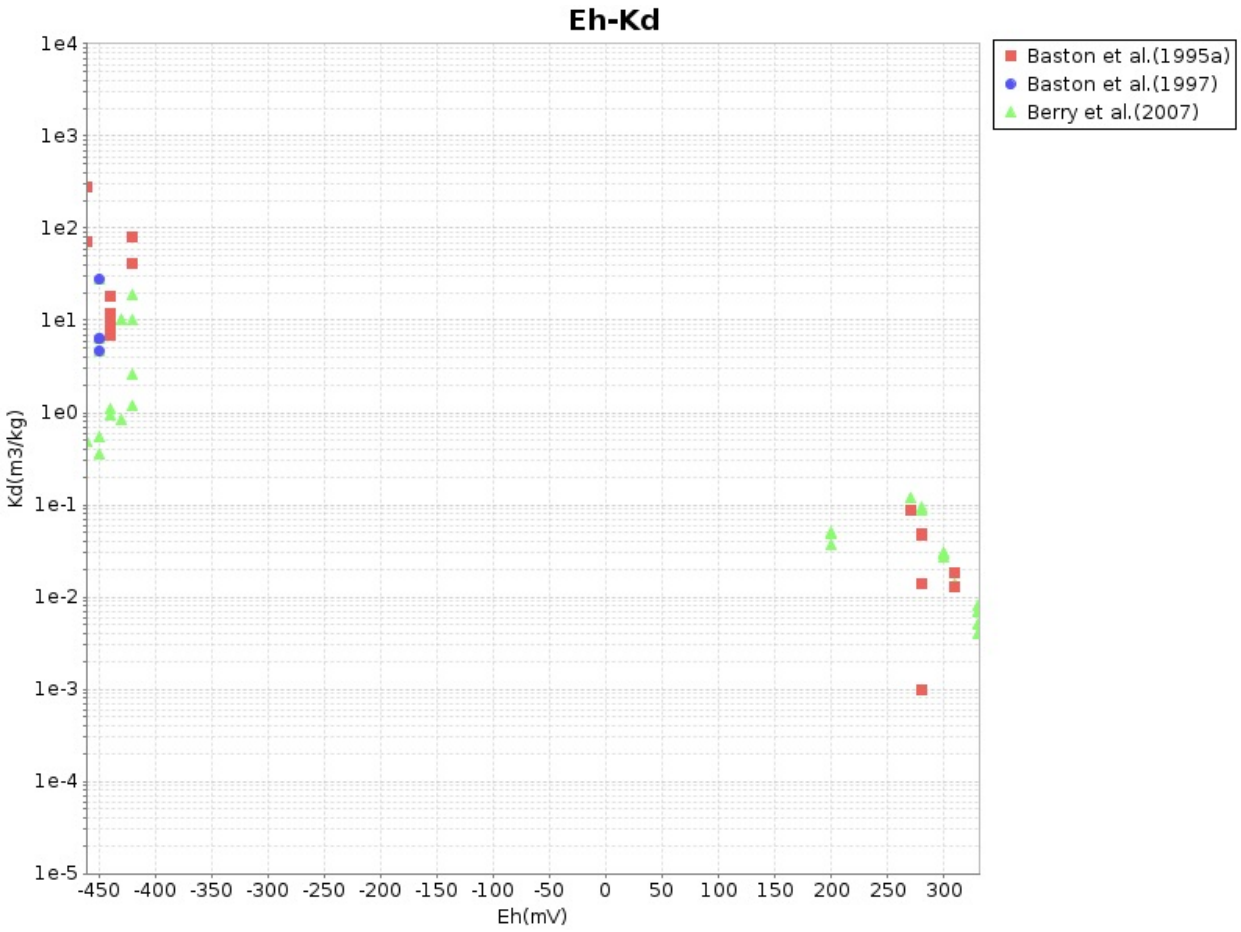


Figure A-8: K_d of U on granite compiled in JAEA database (Eh dependence)

Table A-66: Sorption kinetics data of Eu on IG_BH01_SO001 (biotite granodiorite tonalite) in CR-10 (Oxidizing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	6.8	7.1	300	300	1.13E+03	1.56E+02	9.78E+02	1.24E+03
2	6.7	6.9	310	310	1.33E+03	7.52E+01	1.26E+03	1.38E+07
3	6.8	7	310	300	1.83E+03	5.29E+01	1.78E+03	1.87E+03
7	7.1	6.8	300	300	1.81E+03	8.94E+01	1.72E+03	1.89E+03
14	7.3	6.8	300	310	1.85E+03	5.06E+01	1.80E+03	1.89E+03
21	6.9	7	310	300	1.83E+03	8.52E+01	1.74E+03	1.92E+03

Table A-67: Sorption kinetics data of Eu on IG_BH01_SO001 (biotite granodiorite tonalite) in CR-10 (Reducing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	7.4	7.3	-210	-200	1.49E+03	1.62E+02	1.33E+03	1.60E+03
2	7.3	7.4	-200	-200	1.70E+03	5.64E+01	1.65E+03	1.76E+03
3	7.4	7.1	-220	-210	1.68E+03	5.37E+01	1.63E+03	1.74E+03
7	7.5	7.2	-210	-200	1.76E+03	1.67E+02	1.63E+03	1.92E+03
14	7.2	7.3	-200	-200	1.83E+03	8.47E+01	1.74E+03	1.89E+03
21	7.4	7.4	-210	-210	1.80E+03	4.97E+01	1.76E+03	1.85E+03

Table A-68: Sorption kinetics data of Eu on IG_BH01_SO001 (biotite granodiorite tonalite) in CR-10NF (Reducing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	8.8	9.1	-220	-210	2.16E+03	5.98E+02	1.56E+03	2.49E+03
2	9.1	9.3	-210	-200	1.47E+03	2.95E+01	1.45E+03	1.50E+03
3	9.3	9	-220	-200	1.73E+03	5.27E+01	1.69E+03	1.78E+03
7	8.7	9.1	-200	-210	1.78E+03	9.87E+01	1.71E+03	1.88E+03
14	9	9.3	-210	-200	1.85E+03	7.44E+01	1.78E+03	1.91E+03
21	9.2	9.3	-220	-210	1.83E+03	7.04E+01	1.76E+03	1.89E+03

Table A-69: Sorption kinetics data of Eu on IG_BH01_SO001 (biotite granodiorite tonalite) in CR-0 (Oxidizing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	7.8	7.6	300	300	6.57E+02	4.14E+01	6.22E+02	6.98E+02
2	7.6	7.5	310	310	1.79E+03	8.21E+01	1.70E+03	1.84E+03
3	7.8	7.7	300	310	1.73E+03	2.78E+01	1.71E+03	1.76E+03
7	7.5	7.4	300	300	1.74E+03	3.33E+01	1.71E+03	1.77E+03
14	7.7	7.8	310	300	1.78E+03	4.00E+01	1.74E+03	1.82E+03
21	7.4	7.5	300	300	1.78E+03	6.66E+01	1.74E+03	1.85E+03

Table A-70: Sorption kinetics data of Eu on IG_BH01_SO001 (biotite granodiorite tonalite) in CR-0 (Reducing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	7.8	7.7	-210	-210	3.71E+02	1.75E+01	3.60E+02	3.89E+02
2	7.9	7.8	-230	-200	1.84E+03	6.80E+01	1.77E+03	1.90E+03
3	7.7	7.6	-220	-210	1.75E+03	7.22E+01	1.68E+03	1.82E+03
7	7.8	7.8	-210	-200	1.78E+03	5.65E+01	1.72E+03	1.82E+03
14	7.8	7.7	-200	-200	1.79E+03	3.78E+01	1.77E+03	1.83E+03
21	7.9	7.8	-210	-210	1.78E+03	6.37E+01	1.73E+03	1.85E+03

Table A-71: Sorption kinetics data of Eu on IG_BH05_SO001 (diabase dyke) in CR-10 (Oxidizing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	6.8	7	300	300	1.73E+02	1.13E+02	6.01E+01	2.66E+02
2	6.7	6.9	300	300	5.83E+02	7.80E+01	5.05E+02	6.48E+02
3	6.8	7.1	300	300	1.05E+03	8.21E+01	9.65E+02	1.10E+03
7	7	6.8	300	300	9.57E+02	1.86E+02	7.96E+02	1.14E+03
14	7.1	6.7	300	300	1.13E+03	1.09E+02	1.02E+03	1.23E+03
21	6.9	6.6	300	300	1.08E+03	1.24E+02	9.78E+02	1.20E+03

Table A-72: Sorption kinetics data of Eu on IG_BH05_SO001 (diabase dyke) in CR-10 (Reducing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	7.3	7.5	-200	-200	1.52E+02	5.11E+01	1.11E+02	2.03E+02
2	7.2	7.4	-190	-200	9.04E+02	5.94E+01	8.44E+02	9.40E+02
3	7.2	7.3	-190	-200	9.27E+02	2.16E+02	7.72E+02	1.14E+03
7	7.1	7.2	-190	-200	1.05E+03	1.96E+02	8.56E+02	1.21E+03
14	7.3	7.2	-200	-200	9.62E+02	2.02E+02	7.61E+02	1.16E+03
21	7.3	7.4	-200	-190	1.05E+03	6.45E+01	9.87E+02	1.10E+03

Table A-73: Sorption kinetics data of Eu on IG_BH05_SO001 (diabase dyke) in CR-10NF (Reducing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	8.9	9.3	-200	-200	1.71E+02	8.76E+01	1.12E+02	2.59E+02
2	9	9.2	-200	-200	6.55E+02	1.42E+02	5.13E+02	7.79E+02
3	8.9	9.4	-200	-200	9.56E+02	8.05E+01	8.83E+02	1.04E+03
7	8.9	9.2	-200	-200	1.08E+03	1.03E+02	9.74E+02	1.18E+03
14	8.8	9.3	-200	-200	1.13E+03	1.17E+02	1.04E+03	1.24E+03
21	9.2	9.1	-200	-190	1.03E+03	1.40E+02	8.91E+02	1.12E+03

Table A-74: Sorption kinetics data of Eu on IG_BH05_SO001 (diabase dyke) in CR-0 (Oxidizing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	7.4	7.2	300	300	1.86E+02	5.40E+01	1.32E+02	2.28E+02
2	7.4	7.3	300	300	1.00E+03	9.21E+01	9.11E+02	1.06E+03
3	7.1	7.2	310	300	1.04E+03	1.94E+02	9.35E+02	1.23E+03
7	7.4	7.1	310	300	1.10E+03	1.32E+02	9.65E+02	1.23E+03
14	7.2	7.4	300	300	9.62E+02	1.29E+02	8.33E+02	1.08E+03
21	7.2	7.3	300	300	1.02E+03	8.74E+01	9.52E+02	1.10E+03

Table A-75: Sorption kinetics data of Eu on IG_BH05_SO001 (diabase dyke) in CR-0 (Reducing)

time (d)	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
1	7.8	7.7	-200	-200	1.84E+02	5.66E+01	1.28E+02	2.40E+02
2	7.7	7.6	-200	-200	7.96E+02	1.74E+02	6.22E+02	9.69E+02
3	7.8	7.8	-200	-190	1.01E+03	8.70E+01	9.48E+02	1.10E+03
7	7.8	7.8	-200	-190	1.06E+03	1.01E+02	9.57E+02	1.15E+03
14	7.7	7.9	-200	-200	9.75E+02	1.15E+02	8.60E+02	1.06E+03
21	7.8	7.5	-200	-190	1.07E+03	1.59E+02	9.52E+02	1.23E+03

Table A-76: K_d measurement data of Eu on IG_BH01_SO001 (biotite granodiorite tonalite)

Solution Ox/Re	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
CR-10_OX	7.3	7.3	300	300	1.63E+03	1.60E+02	1.47E+03	1.75E+03
CR-10_OX	7.2	7.2	310	300	1.58E+03	5.55E+01	1.53E+03	1.63E+03
CR-10_OX	7.3	7.1	310	310	1.47E+03	2.00E+02	1.50E+03	1.72E+03
CR-10_RE	7.3	7.2	-200	-210	1.70E+03	1.12E+02	1.58E+03	1.77E+03
CR-10_RE	7.4	7.1	-200	-200	1.68E+03	2.22E+02	1.44E+03	1.86E+03
CR-10_RE	7.2	7.3	-210	-200	1.39E+03	5.31E+02	8.55E+02	1.89E+03
CR-10NF_RE	9.2	9.2	-200	-200	1.53E+03	6.51E+01	1.49E+03	1.59E+03
CR-10NF_RE	9.1	9.3	-210	-210	1.43E+03	1.07E+02	1.33E+03	1.50E+03
CR-10NF_RE	9.4	9.2	-200	-200	1.67E+03	2.90E+02	1.48E+03	1.96E+03
CR-0_OX	7.2	7.4	300	300	1.61E+03	8.52E+01	1.53E+03	1.69E+03
CR-0_OX	7.1	7.3	310	300	1.56E+03	5.33E+01	1.51E+03	1.61E+03
CR-0_OX	7.2	7.4	300	300	1.40E+03	1.59E+02	1.24E+03	1.55E+03
CR-0_RE	7.8	7.5	-210	-200	1.58E+03	1.42E+02	1.47E+03	1.72E+03
CR-0_RE	7.7	7.7	-200	-200	1.70E+03	1.18E+02	1.58E+03	1.79E+03
CR-0_RE	7.6	7.6	-210	-200	1.62E+03	1.19E+02	1.50E+03	1.74E+03

Table A-77: K_d measurement data of Eu on IG_BH01_SO014 (biotite granodiorite tonalite)

Solution Ox/Re	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
CR-10_OX	6.8	6.9	300	310	1.70E+03	1.10E+02	1.62E+03	1.81E+03
CR-10_OX	7	7.1	310	300	1.55E+03	2.07E+02	1.35E+03	1.73E+03
CR-10_OX	6.7	7.1	300	300	1.63E+03	1.89E+02	1.47E+03	1.82E+03
CR-10_RE	7.2	7.2	-210	-200	1.72E+03	2.70E+02	1.56E+03	1.99E+03
CR-10_RE	7.1	7.4	-200	-210	1.79E+03	2.56E+02	1.62E+03	2.05E+03
CR-10_RE	7.4	7.3	-200	-200	1.78E+03	2.91E+01	1.75E+03	1.80E+03
CR-10NF_RE	9.3	9.3	-210	-200	1.84E+03	2.86E+02	1.57E+03	2.13E+03
CR-10NF_RE	9.1	9.2	-220	-200	1.78E+03	1.57E+02	1.67E+03	1.93E+03
CR-10NF_RE	9.2	9.3	-200	-200	1.63E+03	1.47E+02	1.48E+03	1.71E+03
CR-0_OX	7.2	7.4	300	300	1.37E+03	4.29E+02	9.43E+02	1.69E+03
CR-0_OX	7.3	7.1	300	310	1.71E+03	1.42E+02	1.58E+03	1.85E+03
CR-0_OX	7.1	7.2	310	300	1.58E+03	9.79E+01	1.50E+03	1.68E+03
CR-0_RE	7.7	7.7	-210	-210	2.13E+03	2.79E+02	1.85E+03	2.33E+03
CR-0_RE	7.8	7.5	-200	-200	1.75E+03	1.82E+02	1.64E+03	1.93E+03
CR-0_RE	7.7	7.6	-200	-200	1.86E+03	1.71E+02	1.69E+03	1.96E+03

Table A-78: K_d measurement data of Eu on IG_BH03_SO002 (biotite granodiorite tonalite)

Solution Ox/Re	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
CR-10_OX	6.8	6.7	300	300	2.20E+03	5.48E+02	1.65E+03	2.73E+03
CR-10_OX	6.6	6.8	310	300	1.91E+03	2.32E+02	1.68E+03	2.10E+03
CR-10_OX	6.7	6.6	300	300	1.97E+03	2.76E+02	1.73E+03	2.25E+03
CR-10_RE	7.3	7.3	-210	-200	2.20E+03	2.78E+02	2.04E+03	2.48E+03
CR-10_RE	7.3	7.3	-200	-200	2.02E+03	5.15E+02	1.51E+03	2.47E+03
CR-10_RE	7.2	7.4	-200	-210	2.26E+03	2.73E+02	2.07E+03	2.54E+03
CR-10NF_RE	8.9	9.3	-210	-200	1.65E+03	1.13E+02	1.54E+03	1.74E+03
CR-10NF_RE	9	9.2	-210	-200	1.90E+03	3.37E+01	1.87E+03	1.93E+03
CR-10NF_RE	9.1	9.2	-200	-200	1.64E+03	6.06E+02	1.23E+03	2.25E+03
CR-0_OX	7.2	7.2	310	300	1.98E+03	2.34E+02	1.74E+03	2.18E+03
CR-0_OX	7.3	7.2	300	300	2.08E+03	4.94E+02	1.59E+03	2.48E+03
CR-0_OX	7.2	7.4	300	300	1.52E+03	6.13E+02	9.43E+02	2.14E+03
CR-0_RE	7.7	7.8	-210	-200	1.65E+03	2.05E+02	1.50E+03	1.59E+03
CR-0_RE	7.9	7.7	-210	-200	1.65E+03	2.78E+02	1.48E+03	1.94E+03
CR-0_RE	7.7	7.7	-200	-190	1.71E+03	1.95E+02	1.59E+03	1.90E+03

Table A-79: K_d measurement data of Eu on IG_BH03_SO005 (amphibolite)

Solution Ox/Re	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
CR-10_OX	6.8	7.1	300	300	3.50E+03	6.32E+02	2.87E+03	3.96E+03
CR-10_OX	6.6	6.7	310	300	2.75E+03	2.40E+02	2.53E+03	2.99E+03
CR-10_OX	6.8	6.9	300	300	3.15E+03	2.35E+02	2.92E+03	3.32E+03
CR-10_RE	7.4	7.3	-210	-200	4.34E+03	2.85E+03	2.50E+03	7.19E+03
CR-10_RE	7.4	7.3	-210	-210	3.10E+03	3.63E+02	2.74E+03	3.29E+03
CR-10_RE	7.2	7.1	-200	-200	3.38E+03	2.55E+02	3.18E+03	3.63E+03
CR-10NF_RE	9	9.2	-210	-200	3.01E+03	1.77E+03	1.75E+03	4.78E+03
CR-10NF_RE	9.3	9.3	-200	-200	3.69E+03	1.07E+03	3.11E+03	4.76E+03
CR-10NF_RE	9.1	9.3	-200	-200	3.19E+03	4.45E+02	2.91E+03	3.03E+03
CR-0_OX	7.3	7.2	300	300	3.24E+03	6.59E+02	2.84E+03	3.89E+03
CR-0_OX	7.2	7.1	300	300	4.54E+03	1.61E+03	3.59E+03	6.15E+03
CR-0_OX	7.2	7.3	300	300	3.37E+03	5.57E+02	3.08E+03	3.93E+03
CR-0_RE	7.8	7.8	-210	-210	3.65E+03	7.87E+02	3.03E+03	4.44E+03
CR-0_RE	7.7	7.7	-220	-200	4.45E+03	1.09E+03	3.81E+03	5.54E+03
CR-0_RE	7.7	7.5	-200	-200	5.05E+03	1.43E+03	3.68E+03	6.48E+03

Table A-80: K_d measurement data of Eu on IG_BH05_SO001 (diabase dyke)

Solution Ox/Re	$pH_{initial}$	pH_{final}	$Eh_{initial}$ (mV)	Eh_{final} (mV)	K_d (mL/g) average	ΔK_d (mL/g)	K_d_min	K_d_max
CR-10_OX	6.8	6.8	300	300	1.06E+03	1.20E+02	9.36E+02	1.15E+03
CR-10_OX	6.6	6.7	310	300	1.08E+03	1.11E+02	9.91E+02	1.19E+03
CR-10_OX	6.7	6.9	310	300	1.06E+03	1.38E+02	9.19E+02	1.15E+03
CR-10_RE	7.2	7.3	-200	-200	9.75E+02	6.15E+01	9.27E+02	1.04E+03
CR-10_RE	7.2	7.3	-200	-200	1.04E+03	1.39E+02	9.19E+02	1.18E+03
CR-10_RE	7.1	7.4	-200	-200	1.09E+03	1.06E+02	1.02E+03	1.20E+03
CR-10NF_RE	9.4	9.5	-200	-200	1.04E+03	1.14E+02	9.31E+02	1.15E+03
CR-10NF_RE	9.3	9.2	-200	-200	1.04E+03	1.38E+02	9.48E+02	1.17E+03
CR-10NF_RE	9.3	9.4	-200	-210	1.00E+03	1.28E+02	9.15E+02	1.13E+03
CR-0_OX	7.7	7.6	300	300	1.09E+03	6.39E+01	1.05E+03	1.15E+03
CR-0_OX	7.6	7.5	300	300	9.85E+02	7.88E+01	9.31E+02	1.06E+03
CR-0_OX	7.7	7.7	300	300	1.11E+03	2.98E+01	1.08E+03	1.14E+03
CR-0_RE	7.8	7.8	-200	-200	1.08E+03	1.03E+02	9.74E+02	1.16E+03
CR-0_RE	7.8	7.9	-210	-210	9.94E+02	6.26E+01	9.31E+02	1.06E+03
CR-0_RE	7.9	7.6	-210	-200	1.03E+03	1.25E+02	9.31E+02	1.16E+03

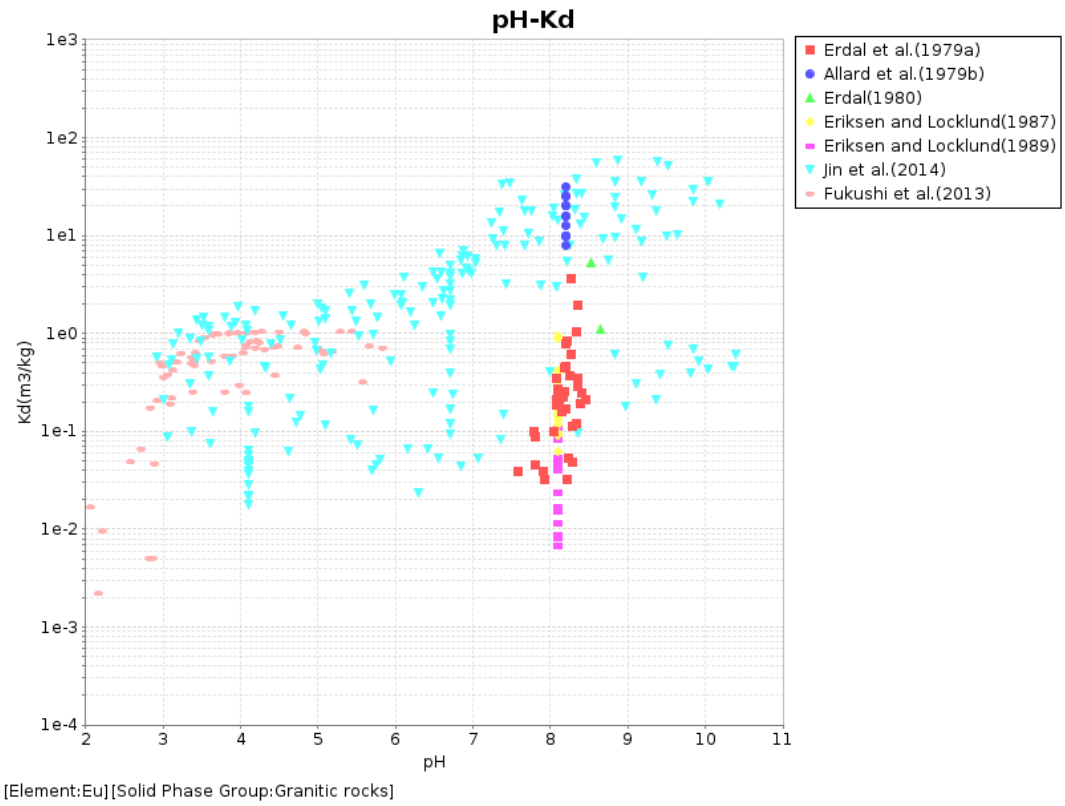


Figure A-9: K_d of Eu on granite compiled in JAEA database (pH dependence)

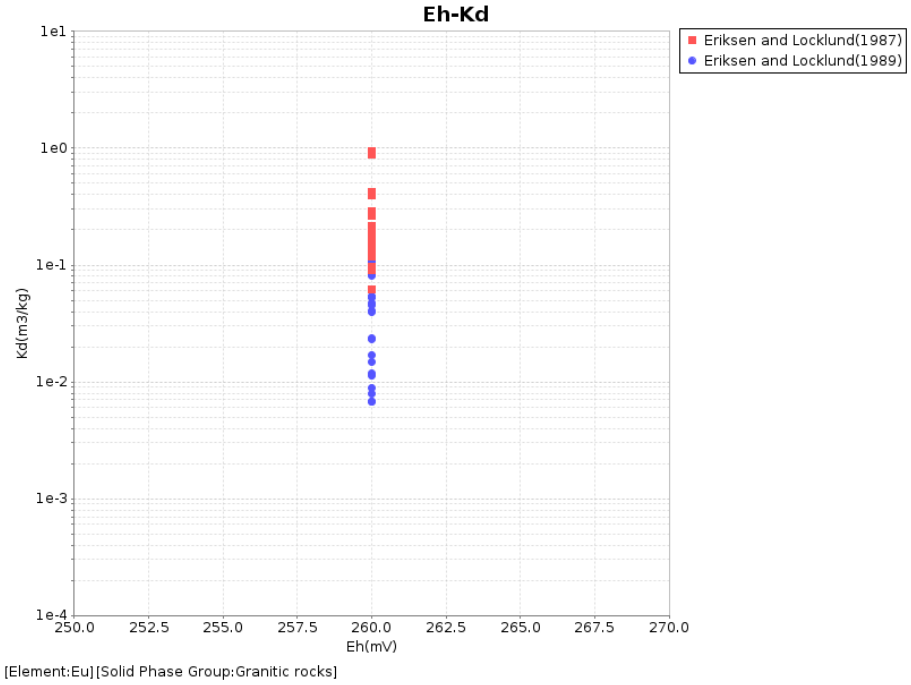


Figure A-10: K_d of Eu on granite compiled in JAEA database (Eh dependence)