

Geology and Geological Structure of Tsuruga
Power Station Site
The D-1 Shatter Zone

The Japan Atomic Power Company
April 24, 2013

Comprehensive evaluation of D-1 shutter zone and K fault

◆ K fault is not D-1 shutter zone and does not extend to the reactor building of Unit 2.

(Thin section observation)

- The displacement sense of K fault is different from that of D-1 shutter zone (including G fault)

K fault: displacement sense of reverse fault
D-1 shutter zone (including G fault): displacement sense of normal fault

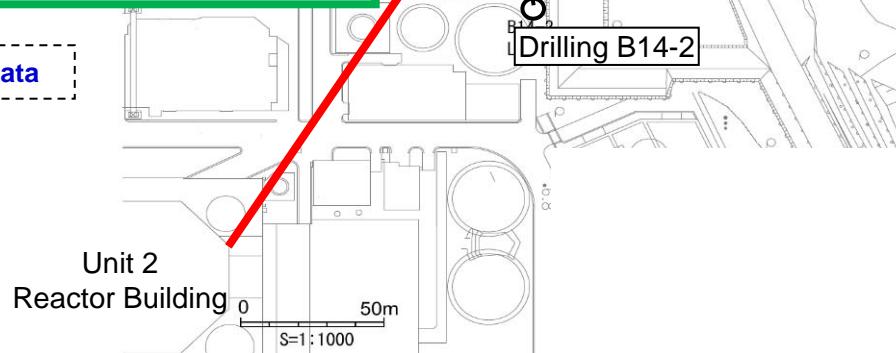
(Additional geologic observation of L-cut pit and western pit)

- K fault reaches to basement rock and the direction of its strike changes from N-S to **NW-SE** in D-1 trench (**confirmed in the basement rock**). It is suggested that K fault does not extend to the reactor building of Unit 2.

(Additional thin section observation of B14-2 drilling)

- At B14-2, which is located to the south of D-1 trench, three fault gouges are found. However each of them does not have reverse fault sense, which is a characteristic of K fault, but has normal fault sense.
- Accordingly, It is judged that K fault does not extend to southern direction at least beyond B14-2 drilling location.

Blue Colored: Newly obtained data



◆ G fault is D-1 shutter zone.

• Strike and dip is similar to each other
(Additional thin section observation)

- Additional thin section observations were performed on the fracture segments that is considered to be D-1 shutter zone (D-1 outcrop, drillings and D-1 trench, **slope behind Unit 2**)
- So both of D-1 shutter zone and G fault have same displacement sense of normal fault that G fault is D-1 shutter zone.

◆ D-1 shutter zone (including G fault) and K fault were not active in and after the Late Pleistocene.

(Additional dating of D-1 trench)

- Both of D-1 shutter zone (including G fault) and K fault is covered by lower part of Layer ⑤. (Both of them have not been active since the deposition of lower part of layer ⑤)
- From the results of additional dating on the lower part of layer ⑤, it is judged that the lower part of layer ⑤ was deposited about 120,000 – 130,000 years ago. (Mihama-tephra was detected. **The tephra was confirmed to be different from DMP. The Hornblende tephra in the layer ③ was confirmed to be different from Mihama-tephra**)
- Accordingly, both of D-1 shutter zone (including G fault) and K fault, which are covered by lower part of Layer ⑤, have not been active since about 120,000 – 130,000 years ago.

D-1 shutter zone and K fault were not active in and after Late Pleistocene. Therefore D-1 shutter zone and K fault are not active faults that should be taken into consideration for the seismic design.

Points of views of the operator and EMS

Evaluation of continuity

The operator's evaluation

We will explain the items written in red today.

EMS's points of views (Basic concepts of evaluation)

Surveys for shatter zone

- The shatter zone was checked by implementing outcrop surveys, boring surveys or trench surveys, etc.
(In the D-1 trench, G fault and K fault were checked)

Evaluations for continuity

- The continuity was evaluated based on the similarities in the strikes and the dips.
- D-1 shatter zone, running directly under the reactor building of the unit 2 and G fault are N-S strikes, while K fault extends the rock mass, the direction of its strike changes from N-S to NW-SE.

As strikes and dips of faults could vary in a sedimentary layer in a lot of cases generally, it is not identified that that K fault shouldn't head for the direction of D-1 shutter zone even though it is winding in the layer.

Confirmation of adequacy for evaluations of continuity

- In order to confirm the adequacy for the continuity of D-1 shatter zone and G fault, the displacement senses of the last slips were focused, as well.
- D-1 shutter zone and G fault are considered to be 'normal fault and right-lateral slip', while K fault is 'reverse fault' (currently under survey).

- There is a case that the structure of the last slip cannot be recognized.
- The latest events of each survey point are not necessarily the same period.

The result of evaluation

D-1 shatter zone continues to the G fault but not to K fault.

- In general, faults are not always extended straight but could sometimes be winding or running parallel after being interrupted.
- It is appropriate to consider that D-1 shatter zone continues to G and K faults.

Evaluation of activity

Selection of survey location for activity evaluation

- D-1 trench was selected, because it is located where Urasoko fault affect easily, and it is based on a consideration that the activity should be sufficiently low under the reactor facility if the shatter zone has not been active.

- The sedimentary layers in which the data to be evidence for the evaluation of activity possibly exists were lost by the past construction and excavation activities and there is no decisive evidence to show that the activity of D-1 shatter zone is high.

Evaluation by overlying strata analysis method

- Mihama-tephra (about 120,000 years ago) was identified in the lower part of layer⑤. (currently under survey)
- G fault and K fault are covered by the lower part of layer⑤.

- Only the Mihama-tephra was analyzed and compared but others.
- Only little number of tephras were detected in the lower part of layer⑤, and they were also included in layer③, which provides little credibility.

The result of evaluation

D-1 shatter zone (including G fault) and K fault are not active fault that should be taken into consideration for the seismic design.

It was identified that K fault made slips in the geological strata which was possible to be deposited after the Late Pleistocene.

Our opinions on 'views against JAPC's claim' (1/5)

(Draft) EMS's views against JAPC's claim concerning the fault evaluations of Tsuruga PS site, EMS on shatter zones in the site of Tsuruga Power Station		JAPC's opinion	Reference No.
Main texts	Issues		
<p><EMS's view on the claim 1> EMS evaluation report (draft) states that the operator has not give clear evidence on that G fault is D-1 shatter zone. The reasons of EMS's views are as follows;</p>	<p>—</p>	<p>—</p>	<p>—</p>
<p>1. In EMS, the specialist of geology pointed out; - <u>It is difficult to identify the displacement sense of the last slip surface by thin section observations, because the structure of the last slip cannot always be identified through clearly distinguishing each slip from the others in case of the fault experienced multiple slips.</u> - Even if the displacement senses of the last slip surfaces is identified at each point, <u>it is only the last slip surface at each point but the slip periods of each point cannot be specified.</u> In other words, <u>the last slip surfaces of different points were not necessarily be active in the same period</u> even if their displacement senses are the same. Therefore, the evaluation based on displacement senses cannot be sufficient evidence for the claim that <u>the G fault continues to the D-1 shatter zone.</u></p>	<p>1. Thin section observations cannot identify displacement senses of the last slip surfaces.</p> <p>2. There is no sufficient evidence for the claim that the G fault continues to the D-1 shatter zone.</p>	<p>(Outline of today's explanation) 1. Identifications of displacement senses of the last slip surfaces - Thin section observations have been implemented for identifying the displacement senses of the faults. In order to verify the validity of thin section observations, CT image analyses for the identification of the last slip surface and slickenline observations with stereoscopic microscope for the identification of the displacement senses were implemented for the D-1 shatter zone (at the slope behind the unit 2), the G fault (at D-1 trench) and the K fault (at D-1 trench). - The result shows that there was no problem in the identifications of the last slip surfaces based on the thin section observations which have been implemented so far and the displacement senses were consistent with the ones identified by the slickenline observations. - Therefore, it is possible to identify the displacements sense of the last slip surface by thin section observations.</p> <p>2. Continuity of D-1 shatter zone - The strike and the dip of the G fault are similar to the ones of the D-1 shatter zone (N-S strike / high angle west-dipping) and the displacement senses of their last slip surfaces were also the same, which are normal faults. - Meanwhile, the K fault was a reverse fault which is different from the D-1 shatter zone. - Therefore, the K fault is not the D-1 shatter zone but the G fault.</p> <p>(Point to be clarified by EMS) - The reasonable reason that EMS claims the active periods of the shatter zones with the same displacement sense are different, and there can be many shatter zones which continue to the D-1 shatter zone.</p>	<p>10-45</p>

Our opinions on 'views against JAPC's claim' (2/5)

(Draft) EMS's views against JAPC's claim concerning the fault evaluations of Tsuruga PS site, EMS on shatter zones in the site of Tsuruga Power Station		JAPC's opinion	Reference No.
Main texts	Issues		
<p><EMS's views on the claim 2></p> <p>The evaluation report states that the K fault is 'the structure which continues to the D-1 shatter zone'. The reasons are as follows;</p> <p>(1) As stated in the 'Claim 1', the specialist of geology pointed out as follows, concerning the thin section observations implemented for the G fault and the D-1 shatter zone;</p> <p>- (Skipped)</p> <p>In this way, EMS considers that <u>the evaluation of displacements are not reliable and provides insufficient evidence for the claim that there is no connection between the K fault and the D-1 shatter zone.</u></p>	<p>Same as the Claim 1.</p>	<p>Same as our view on the Claim 1 in the EMS.</p>	<p>—</p>
<p>(2) Especially, the point where the strike of the K fault is bent to the NNW – SSE direction* was <u>recognized mainly in the deposits above the bedrock</u>. In general, the strikes and dips of the faults found in deposits are not constant and they could vary from place to place. Therefore, <u>it is not possible to conclude that the K fault does not head for the direction of the D-1 shatter zone just because the fault in the deposit is bent.</u></p> <p>(3) In addition, <u>faults are not necessarily be extended linearly but turning to the different directions or running parallel after they are once broken, in general. The D-1 shatter zone is considered to have such forms.</u></p> <p><small>* In the JAPC's report dated April 24, 2003, the direction is described as "NW-SE direction."</small></p>	<p>1. It has been identified that the K fault was bent in the deposit and the assumption is not credible.</p> <p>2. Because faults are generally bent or running parallel after they are once broken even if they are bent, the D-1 shatter zone is considered to continue to the K fault.</p>	<p>(Outline of today's explanation)</p> <p>1. Forms in the K fault bedrock</p> <ul style="list-style-type: none"> - In the EMS so far, JAPC has repeatedly said that additional surveys are implemented for extension of the K fault to the bedrock. - Based on the EMS's comment that the D-1 shatter zone is not necessarily be extended linearly, surveys have continuously been implemented along the strike of the D-1 shatter zone, considering increasing of the survey points as much as possible. - The pit survey in the D-1 trench confirmed that the strike of the K fault changes to the NW-SE direction also in the bedrock (prompt report). <p>2. Extension of the K fault to the south direction</p> <ul style="list-style-type: none"> - According to the thin section observation of the B14-2 drilling between the unit 2 reactor building and the D-1 trench, there was no shatter zone with reverse fault sense which the K fault has at all. Therefore, the K fault is not extended further south than the B14-2 drilling. <p>(Point to be clarified by EMS)</p> <ul style="list-style-type: none"> - EMS's evidence that 'the D-1 shatter zone is considered to have such forms'. 	<p>46-60</p>

Our opinions on 'views against JAPC's claim' (3/5)

(Draft) EMS's views against JAPC's claim concerning the fault evaluations of Tsuruga PS site, EMS on shatter zones in the site of Tsuruga Power Station		JAPC's opinion	Reference No.
Main texts	Issues		
<p><EMS's views on the claim 3> (1) The operator's claim that D-1 fault is not the active fault to be taken into consideration. > (Skipped)</p>	—	<p>(Original thoughts)</p> <ul style="list-style-type: none"> - Though the detected amount is small, hornblendes are broadly distributed in the same horizon while Kojaku granites or dolerites which compose the rock mass do not include hornblende. Therefore, it is considered to the amphibolite which originate in the tephra. - Although somewhat re-deposition of layer is indicated by the repeated change of amounts of amphibolite with increasing and decreasing along up and down direction, the lower occurrence limit is present on or above the bottom of layer⑤, therefore it is judged that the bottom of layer⑤ and the lower occurrence limit almost indicate the period in which the tephra was fallen. - From the points above, there is not problem in the identification method. 	—
<p>(2) Identification of the tephra by analyzing minerals > As for analyzing the minerals contained in tephra, it is general to compare with main components of the several types of tephra to be concerned. However, the operator determined it is the same tephra <u>only by comparing with the tephra, dating back to approx. 120 – 130 thousand years ago (the operator calls it 'Mihama tephra')</u> and the <u>identification method is considered to be insufficient.</u></p> <p>(3) Specification of the deposit which contains the tephra > Since the content percentage of the mineral (amphibolite) detected by the lower part of layer⑤ is <u>low frequency which is less than one per 3,000 counts, and small amount of the mineral (amphibolite) are included in layer③</u> that is lower level, the operator's claim that the lower part of layer⑤ is deposited with the tephra, dating back to 120 – 130 thousand years ago is not reliable assumption. > In order to specify the layer in which the tephra is deposited, it is preferable to recognize volcanic ashes by checking them with eyes. If it is not available with the eye inspection, there is also a way to specify the age, applying the method to count the minerals contained in the tephra in the layer. In that case, <u>it is difficult to specify the layer in which the tephra is deposited unless large amount of minerals are contained in the layer while there is significant difference between the upper and the lower layers.</u></p>	<ul style="list-style-type: none"> - The result of main components analysis has only been compared with Mihama tephra. - The contents of the minerals is low frequency, and it cannot be specified as the layer in which the tephra is deposited unless there is a significant difference between the upper and the lower layers. - Amphibolite is also included in layer③. 	<p>(Outline of today's explanation (new data))</p> <ol style="list-style-type: none"> 1. Stratigraphy of D-1 trench => Layer⑤ was deposited in the warm period, while deposit period of layer③ was colder than layer⑤. 2. Regarding hornblendes included in the lower part of layer⑤ and layer③ => Significant difference has been recognized between the hornblende in lower part of layer ⑤ and the one in layer③ in a result of main composition analysis, although mineral products are quite little because they are gravel. => It was identified that the hornblendes produced in the specific layer of the lower part of layer③ was the amphibolite which originated in the tephra. => It was identified that the lower part of layer⑤ was not the re-deposition of layer③ . 3. Hornblendes detected in the lower part of layer⑤ => There is a high possibility that the hornblendes in the lower part of the layer⑤ is Mihama tephra. => Daisen-Hiruzenpara and BT37 are distributed lower than Sanbe-Kisuki (110-115Ka), which are the tephra, deposited in the marine isotope stage 5e. => Therefore, it is considered that the lower part of layer⑤ should be the deposit of the marine isotope stage 5e. => Layer③ is deposit in marine oxygen isotope stage 6 or before, with consideration that layer③ is lower and colder than layer⑤. <p>In addition,</p> <ul style="list-style-type: none"> - additional analyses are implemented by increasing the survey lines in the D-1 trench in order to be progress of the reliability. - the main components are to be identified as for Daisen-Hiruzenbara. - BT 37 is 127.6ka according to the existing literature though it cannot to be confirmed as it is difficult to obtain the sample. <p>(Points to be clarified by EMS)</p> <ul style="list-style-type: none"> - Considering the above, is there still the reason that the lower part of layer⑤ and layer③ are not respectively MIS5e and MIS6? - The EMS confirmed that the geologic layer where the deformation of the K fault ran up did not reach to the silt layer of layer③. 	61-78

Our opinions on 'views against JAPC's claim' (4/5)

(Draft) EMS's views against JAPC's claim concerning the fault evaluations of Tsuruga PS site, EMS on shatter zones in the site of Tsuruga Power Station		JAPC's opinion	Reference No.
Main texts	Issues		
<p><EMS's views on the claim 4></p> <p>The evaluation document points out that the D-1 shatter zone could give impacts on the important facilities, by being active working together with the activity of the Urasoko fault near there.</p> <p>This is because the K fault which continues to the D-1 shatter zone is a reverse fault accompanied by left-lateral slip and <u>the possibility it would move, lead by the activity of the Urasoko fault is high as it is extremely close to the Urasoko fault, which is 20 – 30m at the horizontal distance.</u></p> <p>In addition, the numerical analysis implemented by the operator is the evaluation based on the 'elasticity theory of dislocation'; however, <u>the specialists of seismic back-check in the former Nuclear and Industrial Safety Agency pointed out that it was difficult to confirm the impacts, applying the 'elasticity theory of dislocation' in case it is too close like the case of the Urasoko fault.</u> The EMS <u>inherited</u> the stance.</p>	<ol style="list-style-type: none"> 1 . <u>The possibility that the D-1 shatter zone would become active, lead by the activity of the Urasoko fault is high.</u> 2 . <u>The EMS inherited the opinion of the specialists of seismic back check in the former Nuclear and Industrial Safety Agency that it is difficult to confirm the impacts, applying the 'elasticity theory of dislocation' in case it is too close like the case of the Urasoko fault.</u> 	<p>(Outline of today's explanation (Original thoughts))</p> <ul style="list-style-type: none"> - The operator implemented the evaluation for the simultaneous activities of the D-1 shatter zone and the Urasoko fault <u>based on the activity record and the numerical analysis.</u> <p><Evaluation based on the activity record></p> <ul style="list-style-type: none"> - The latest activity period of the Urasoko fault is after approx. 4000 years ago and the average interval of the activity is 5,000 years \pm 2,000 years (AIST, etc 2012); however, the D-1 shatter zone has not been active at least since approx. 120,000 years ago. - <u>Therefore, it is considered that the Urasoko fault has become active 10 – 40 times since approx. 120,000 years ago while the D-1 shatter zone has never been active in that period.</u> - In addition, <u>it is considered that the Urasoko fault and the D-1 shatter zone should not simultaneously become active in future, too,</u> considering the view that the regional stress field has not changed since the Late Pleistocene. <p><Evaluation based on the numerical analysis></p> <ul style="list-style-type: none"> - The bearing capacity of the ground which contains the D-1 shatter zone when being impacted by the activity of the Urasoko fault is evaluated by implementing the numerical analysis. - In the numerical analysis, 'basic study' and 'study to consider uncertainty' were implemented first in the ground deformation analysis based on the 'elasticity theory of dislocation' which assumes the ground as an elastic half-space to extract the evaluation conditions <u>for obtaining the most strict result</u> for the bearing capacity evaluation of the reactor building foundation. - After that, it was analyzed based on the evaluation conditions, <u>applying the FEM model which is made, considering the topography, the ground structure, the ground property and the nonlinearity of the ground, etc for which the 'elasticity theory of dislocation' cannot be applied in detail while the stability of the shatter zone was evaluated based on the local safety factor obtained from the FEM analysis result.</u> - Though the result shows shear failures and induction of tensile stresses in the shatter zone near the Urasoko fault, the area is limited while the local safety factor of the shatter zone near the building is sufficiently large. Therefore, it is concluded that <u>the bearing capacity of the ground is sufficiently strong.</u> <ul style="list-style-type: none"> • In addition, the purpose of the numeric analysis implemented by the operator is to evaluate 'if the shatter zone under the reactor building could be broken by the tensile stress in the ground induced due to the activity (displacement) of the Urasoko fault' and it is the evaluation for the ground stability, in other words. • Therefore, it is not the evaluation for calculating the displacement magnitude of the shatter zone. • Such method for the ground stability evaluation is widely applied in the field of geotechnology. <p>(Points to be clarified by EMS)</p> <ul style="list-style-type: none"> • The operator has been implementing the evaluations for the simultaneous activities of the D-1 shatter zone and the Urasoko fault based on the following process and is that correct? - 'The regulatory guide for reviewing seismic safety design of nuclear facilities for power generation (approved by Nuclear Safety Commission as of December 20, 2010) instructed that the fault displacements due to earthquakes should be evaluated by calculating the displacements / deformations of the ground where buildings and structures are established due to the fault displacements. <u>Complying with the guideline, the evaluation was implemented by the numeric analysis to identify whether a gap could be made or not due to the activity of the Urasoko fault in the surrounding shatter zone including the D-1 shatter zone.</u> - Being instructed by the former NISA as of November 11, 2011 'to show the evaluation method of the geological displacements around the active layers in Tsuruga NPP and implement impact evaluations for the reactor building, etc, applying the concerned method', <u>we have been implementing the evaluations.</u> - The operator presented the additional survey plan of the site in the opinion hearing meeting of the former NISA regarding earthquakes and tsunamis as of May 14, 2012 and explained that 'it is evaluated <u>comprehensively</u> based on the results of various geological surveys and <u>the numerical analysis,</u> etc in case it is difficult to evaluate it by overlying strata analysis method'. • The former NISA discussed that 'it should take time to review the applicability' and 'it is necessary to evaluate more in detail' as for the elasticity theory of dislocation; however, it only pointed out that the theory should be evaluated carefully but did not mean that it was inapplicable. • In addition, though the EMS expressed that 'they would inherited the stance', the EMS and 'The study team on the new safety design standards for earthquakes and tsunamis for light water reactors for electric power generation' have not discussed the application of the elasticity theory of dislocation, at all. We would like to know the process how they reached to the conclusion to inherit the stance. • Though the possibility that the D-1 shatter zone could move, lead by the activity of the Urasoko fault was pointed out, we would like to know what sort of mechanism was assumed when you meant by 'lead by the activity' and how large the impact would be. 	79-135

Our opinions on 'views against JAPC's claim' (5/5)

(Draft) EMS's views against JAPC's claim concerning the fault evaluations of Tsuruga PS site		JAPC's opinion	Reference No.
Main texts	Issues		
<p>【EMS views to Claim 5】 The current seismic design policies stipulate that an active fault given consideration in the seismic design is a “fault with signs of activity after the Late Pleistocene that cannot be denied.” It is not stipulated that an active fault is a “fault, of which signs of activity are recognized.” So, to be of concern here is a case with no data relevant to activity available (with no data available proving no activity is found whatsoever). On the occasion that the operator does not present a data accurate enough, like this time, a fault in question is to be judged as an “active fault given consideration in the seismic design.” EMS also considers that <u>the operator is primarily held accountable for proving that a fault is not an active fault.</u> Thus, the operator, which conducted surveys, has a responsibility to present data relevant to fault activity (showing there is no activity whatsoever). In case a new fact emerges, this evaluation might be reviewed, if necessary. Even on that occasion, though, the operator needs to present a set of “objective data” denying any possibility that a fault under survey is not active through further surveys etc.</p>	<ul style="list-style-type: none"> • Whether the operator is primarily held accountable for having the burden of proof? 	<p>From the legal point of view, we consider as inappropriate that the operator is primarily held for having the burden of proof.</p> <p>Generally speaking, under the regulation laws, it is authorities, as an administrator of regulations, that are accountable for proving whether a subject matter in case makes up regulatory requirements. To that end, authorities are entitled to the right of collection of reports and the right to make on-site inspections. Pursuant to new backfitting rules under the Nuclear Reactor Regulation Law, the Nuclear Regulation Authority (or EMS) is authorities found relevant to the case in question and is responsible for having the burden of proof and making final explanations.</p> <p>We already presented to EMS highly accurate and objective facts and data based on surveys to prove that there are “no signs of activity.” If the NRA (or EMS) tries to overturn our position, it will be held accountable for having the burden of proof, or verifying its position, and making explanations on the given data.</p>	136-138

Our opinions on 'EMS's evaluation' (1/2)

(Draft) Evaluation on the faults at Tsuruga PS site (Basic consideration) EMS on shatter zones in the site of Tsuruga Power Station		JAPC's opinion	Reference No.
Main texts	Issues		
<p>① <u>Highly active Urasoko fault</u> is in the extremely close vicinity of Unit 1 and 2 nuclear reactor buildings (about 200-300m apart) within the premises of Tsuruga plant.</p> <ul style="list-style-type: none"> In 2008, JAPC reported that Urasoko fault had been active more than once over the past 120,000-130,000 years and that its latest period of activity must have been more recent than around 4,000 years ago from now. 	—	<p>(Points to be clarified by EMS)</p> <ul style="list-style-type: none"> Urasoko fault is active fault to be taken into account in seismic design. Its affect is evaluated. 	—
<p>② <u>A lot of faults are identified</u> in the premises. <u>Around D-1 fault (or around a line extended from the fault)</u>, which is directly below Unit 2 reactor building, are <u>several faults, including K fault and G fault, which run in parallel in the same direction</u>.</p>	Expert view to JAPC Same as point of contention in Claim 1	Same as our view to expert views to Claim 1	—
<p>③ Generally speaking, a fault does <u>not necessarily stretch out straight. It sometimes inflects, changes direction, or continues running in parallel to other faults after breaking up once</u>. Because of this, it is considered appropriate that D-1 fault, K fault, G fault are in the associated structures.</p>	Expert view to JAPC Same as point of contention in Claim 2	Same as our view to expert views to Claim 2	—
<p>④ It was confirmed that <u>K fault, considered associated structure with D-1 fault, caused an inconsistency in a layer likely to have been piled up from Late Pleistocene</u> on in D-1 trench.</p> <p>Therefore, to judge D-1 fault inactive (which means it has no need to be take into account in seismic design), it should be proven by highly accurate data that there is no new seismic activity in the structure for sure.</p>	<ol style="list-style-type: none"> Didn't identify which layers are likely to have piled up from Late Pleistocene on. Didn't identify which layer caused inconsistency. 	<p>(Points to be clarified by EMS)</p> <ul style="list-style-type: none"> Please provide a concrete reasoning, based on which experts say that "K fault caused inconsistency in a layer likely to have piled up from the Late Pleistocene on," while never explaining the relationship between sedimentary layers and faults and the period evaluation of sedimentary layers. 	—
<p>⑤ Although the operator presented several data so far, <u>all of these data are not recognized as proven enough to say that D-1 fault is inactive</u>.</p> <p>【See attachment for examples】 "Specification of active periods of D-1 fault by observing tephra" "Specification of displacement sense by observing fragment samples" etc.</p>	—	<p>(Points to be clarified by EMS)</p> <ul style="list-style-type: none"> If there are imperfect parts, further data should be added and confirmed. Thus, EMS experts should clarify what is imperfect. 	—
<p>⑥ As most of the layers, on which data was highly likely to have existed and have served as a reasoning for the activity of any fault, were lost in past digging or construction works, it is almost impossible to obtain any decisive evidence for that D-1 fault is highly active.</p> <p>However, the operator says that in the investigation this time it <u>obtained data showing repeated movements of a fault (K fault)</u>, of which a certain amount of rationality is recognized in saying that it is associated with D-1 fault.</p>	—	<p>(Opinions so far expressed)</p> <ul style="list-style-type: none"> D-1 trench is not necessarily considered as inadequate as a position for investigation. The reason for the above, as pointed out in EMS, the objective of the investigation is whether D-1 fault moves in tandem with Urasoko fault. The investigation is underway extremely close to Urasoko fault, because the area under investigation is considered most vulnerable to the fault's activity. <p>(Points to be clarified by EMS)</p> <ul style="list-style-type: none"> At the third meeting, we just said that slickenlines which have several directions are confirmed in L-cut pit. There is no fact that we made any explanation whatsoever suggesting that data was obtained which shows repeated movements in the current stress field. 	—

Our opinions on 'EMS's evaluation' (2/2)

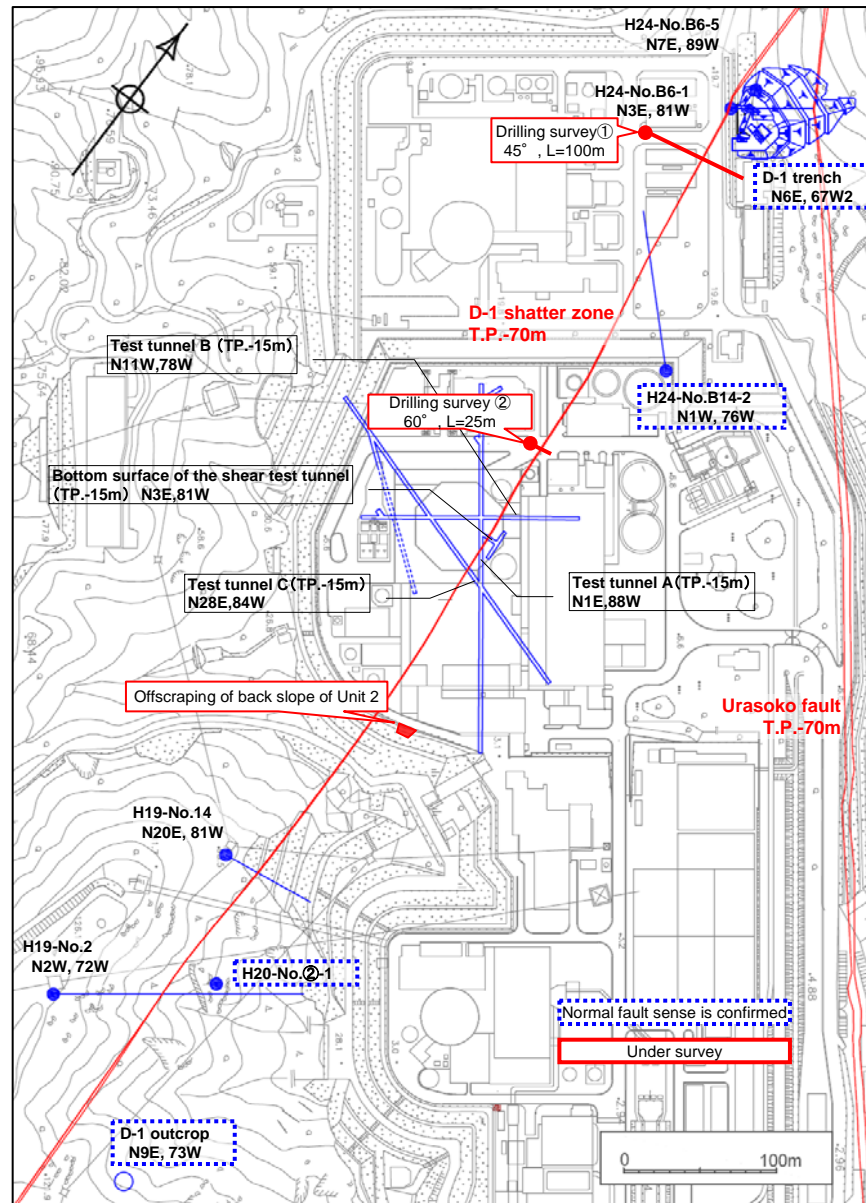
(Draft) Evaluation on the faults at Tsuruga PS site (Basic consideration) EMS on shatter zones in the site of Tsuruga Power Station		JAPC's opinion	Reference No.
Main texts	Issues		
<p>⑦ On data available as of now (including data presented by the operator at Mar. 8 evaluation meeting), EMS defines that D-1 shatter zone is highly likely to be an active fault, which should be taken into account in seismic design and that it is likely to move in sync with Urasoko fault nearby, which means there is a fear to affect important nuclear facilities located immediately above the zone.</p>	—	<p>(Opinion so far expressed)</p> <ul style="list-style-type: none"> Based on each of the above discussions ①~⑥, we judge that D-1 shatter zone is not an active fault, which should be taken into account in seismic design. 	—
<p>⑧ In case another new fact emerges, it may be possible to review the evaluation. However, even on that occasion, the operator needs to provide objective data, or a result of added surveys, which denies any possibility that this is an active fault.</p>	—	<p>(Opinion so far expressed)</p> <ul style="list-style-type: none"> As for evaluation of D-1 shatter zone, we are taking an additional survey to accumulate data. 	—
<p>【See attachment】 Examples of attested information provided by the operator, which was later found inadequate</p> <p>1. Insistence of the active period of D-1 shatter zone by identifying tephra</p> <p>(1) The operator says that D-1 shatter zone is not an active fault to concern >(Same as Claim 2)</p> <p>(2) Identification of tephra through analysis of minerals >(Same as Claim 3)</p> <p>(3) Specification of layer, where tephra accumulates >(Same as Claim 3)</p>	<p>Expert views to JAPC same as noted as points of contention in Claims 2 and 3</p>	<p>Same as our opinions on the left</p>	—
<p>(Expert comment)</p> <p>The following comment is made by Prof. Takehiko Suzuki of Tokyo Metropolitan University, expert at fourth tephra studies (pyroclastic material). <u>Prof.: Before going into the substance of the matter, please note that this comment may not be accurate without details.</u></p> <p>"It would be more persuasive, if a string of samples were extracted by 10cm from a 1m-wide loamy layer, that 100 phenocryst minerals were detected out of 3,000 minerals counted in a certain horizon, and that 30 phenocryst minerals were further detected immediate above and below that horizon, as well as that 10 such minerals were further detected immediate above and below that horizon. If there is only less than one phenocryst mineral out of 3,000 minerals in a certain horizon alone in that layer and that no phenocryst mineral was detected immediate above and below that horizon, I should say that credibility is low, however. (extraction)</p>	—	<p>(Opinions so far expressed)</p> <ul style="list-style-type: none"> Though the detected amount is small, hornblendes are broadly distributed in the same horizon while Kojaku granites or dolerites which compose the rock mass do not include hornblende. Therefore, it is considered to the amphibolite which originate in the tephra. Although somewhat re-deposition of layer is indicated by the repeated change of amounts of amphibolite with increasing and decreasing along up and down direction, the lower occurrence limit is present on or above the bottom of layer ⑤, therefore it is judged that the bottom of layer⑤ and the lower occurrence limit almost indicate the period in which the tephra was fallen. From the points above, there is not problem in the identification method. 	—
<p>2. Specification of displacement sense by fragment observations (Same as Claims 1 and 2)</p>	<p>Expert views to JAPC are the same as Claims 1 and 2</p>	<p>Same as our opinion on the left</p>	—

(Draft) EMS's views against JAPC's claim concerning the fault evaluations of Tsuruga PS site, EMS on shatter zones in the site of Tsuruga Power Station		JAPC's opinion	Reference No.
Main texts	Issues		
<p><EMS's view on the claim 1> EMS evaluation report (draft) states that the operator has not give clear evidence on that G fault is D-1 shatter zone. The reasons of EMS's views are as follows;</p>	—	—	—
<p>1. In EMS, the specialist of geology pointed out; - <u>It is difficult to identify the displacement sense of the last slip surface by thin section observations, because the structure of the last slip cannot always be identified through clearly distinguishing each slip from the others in case of the fault experienced multiple slips.</u> - Even if the displacement senses of the last slip surfaces is identified at each point, <u>it is only the last slip surface at each point but the slip periods of each point cannot be specified.</u> In other words, <u>the last slip surfaces of different points were not necessarily be active in the same period</u> even if their displacement senses are the same. Therefore, the evaluation based on displacement senses cannot be sufficient evidence for the claim that <u>the G fault continues to the D-1 shatter zone.</u></p>	<p>1. Thin section observations cannot identify displacement senses of the last slip surfaces.</p> <p>2. There is no sufficient evidence for the claim that the G fault continues to the D-1 shatter zone.</p>	<p>(Outline of today's explanation) 1. Identifications of displacement senses of the last slip surfaces - Thin section observations have been implemented for identifying the displacement senses of the faults. In order to verify the validity of thin section observations, CT image analyses for the identification of the last slip surface and slickenline observations with stereoscopic microscope for the identification of the displacement senses were implemented for the D-1 shatter zone (at the slope behind the unit 2), the G fault (at D-1 trench) and the K fault (at D-1 trench). - The result shows that there was no problem in the identifications of the last slip surfaces based on the thin section observations which have been implemented so far and the displacement senses were consistent with the ones identified by the slickenline observations. - Therefore, it is possible to identify the displacements sense of the last slip surface by thin section observations.</p> <p>2. Continuity of D-1 shatter zone - The strike and the dip of the G fault are similar to the ones of the D-1 shatter zone (N-S strike / high angle west-dipping) and the displacement senses of their last slip surfaces were also the same, which are normal faults. - Meanwhile, the K fault was a reverse fault which is different from the D-1 shatter zone. - Therefore, the K fault is not the D-1 shatter zone but the G fault.</p> <p>(Point to be clarified by EMS) - The reasonable reason that EMS claims the active periods of the shatter zones with the same displacement sense are different, and there can be many shatter zones which continue to the D-1 shatter zone.</p>	10-45

【Displacement sense of D-1 shatter zone】

Survey location : Back slope of Unit 2

D-1 shatter zone, Offscraping of back slope of Unit 2, Survey location



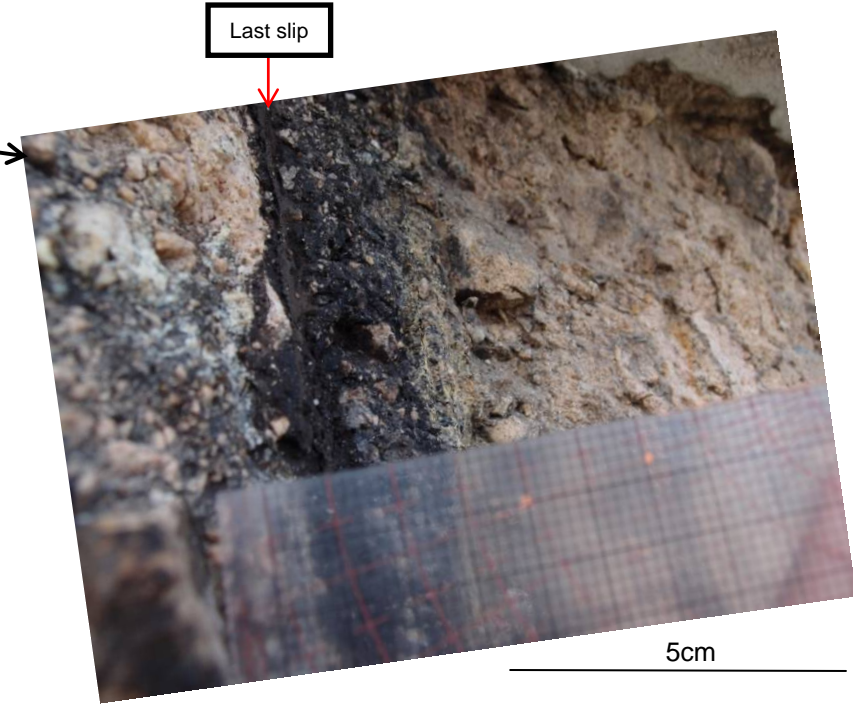
Offscraping of the back slope of Unit 2 was carried out and the data of continuity of D-1 shatter zone was reinforced.

D-1 shatter zone, Offscraping of back slope of Unit 2, Outcrop



Offscraping of slope (full view) 1m

Brown and blackish brown colored fault gouge linearly shears whole of the outcrop.



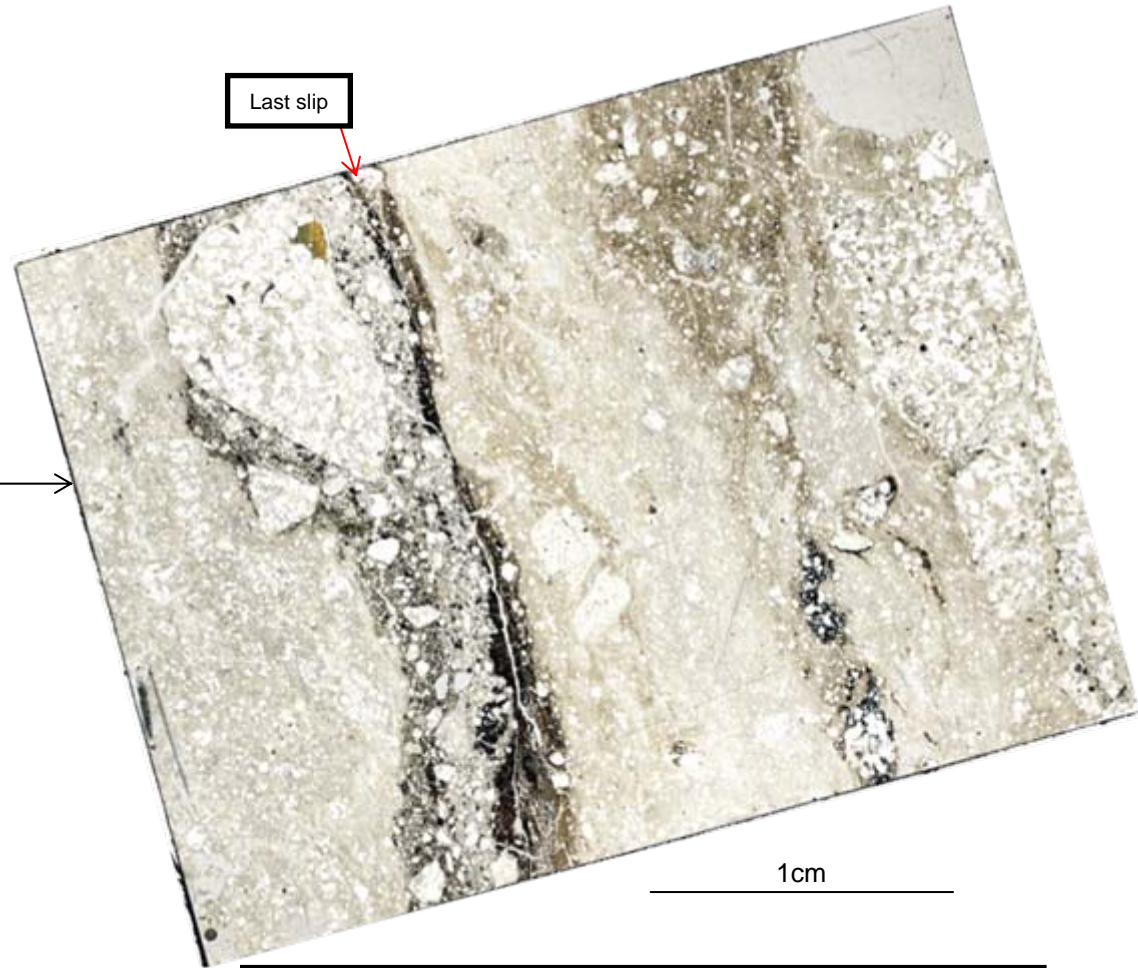
Brownish, thin and soft fault gouge linearly shears other fault gouges around it.

The last slip surface shears whole of the outcrop. That surface is located at the softest portion and has the most rectilinear shape.

D-1 shatter zone, Offscraping of back slope of Unit 2, Polished section

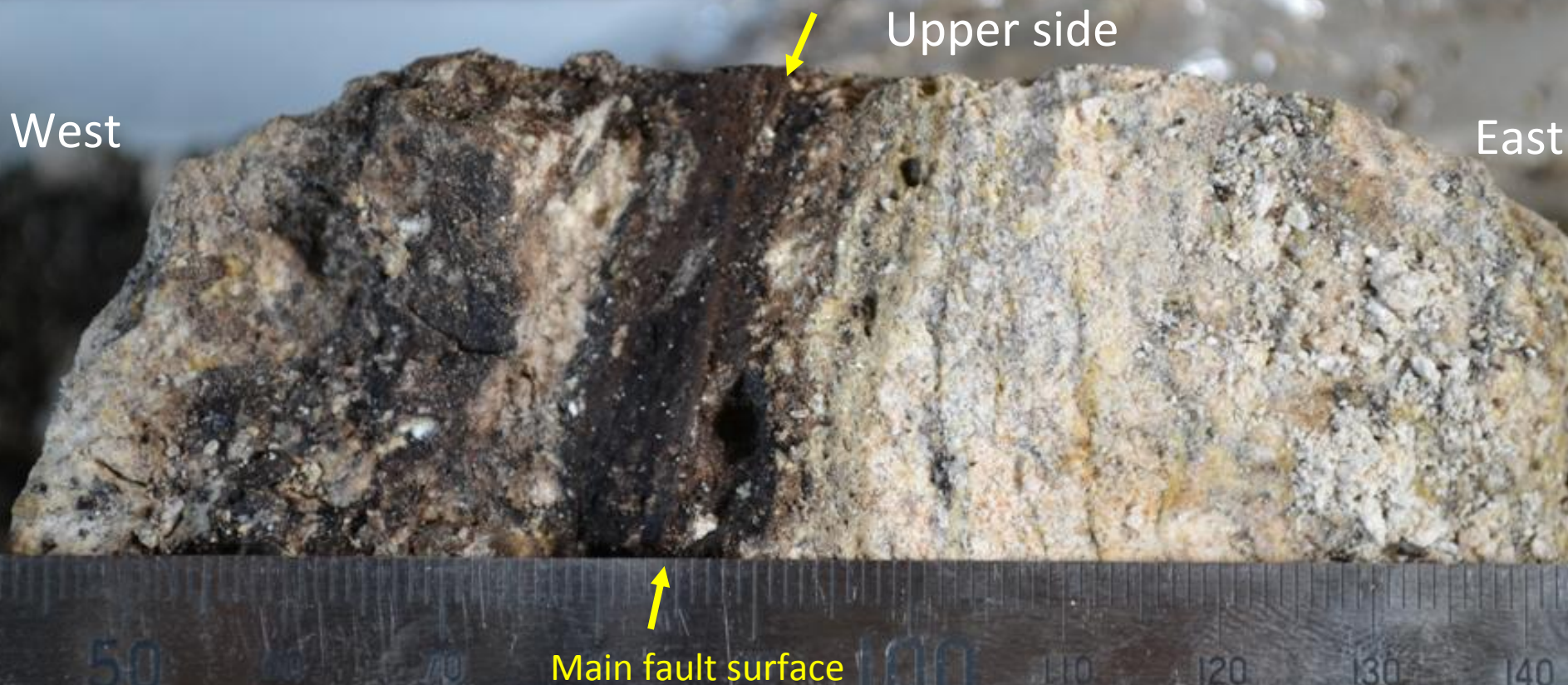


Brownish and thin fault gouge linearly shears whole section.

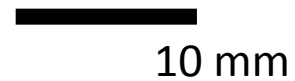


Brownish fault gouge linearly shears whole section.

In the block sample, the last slip surface linearly shears whole of the section. That surface is located at the softest portion and has the most rectilinear shape.

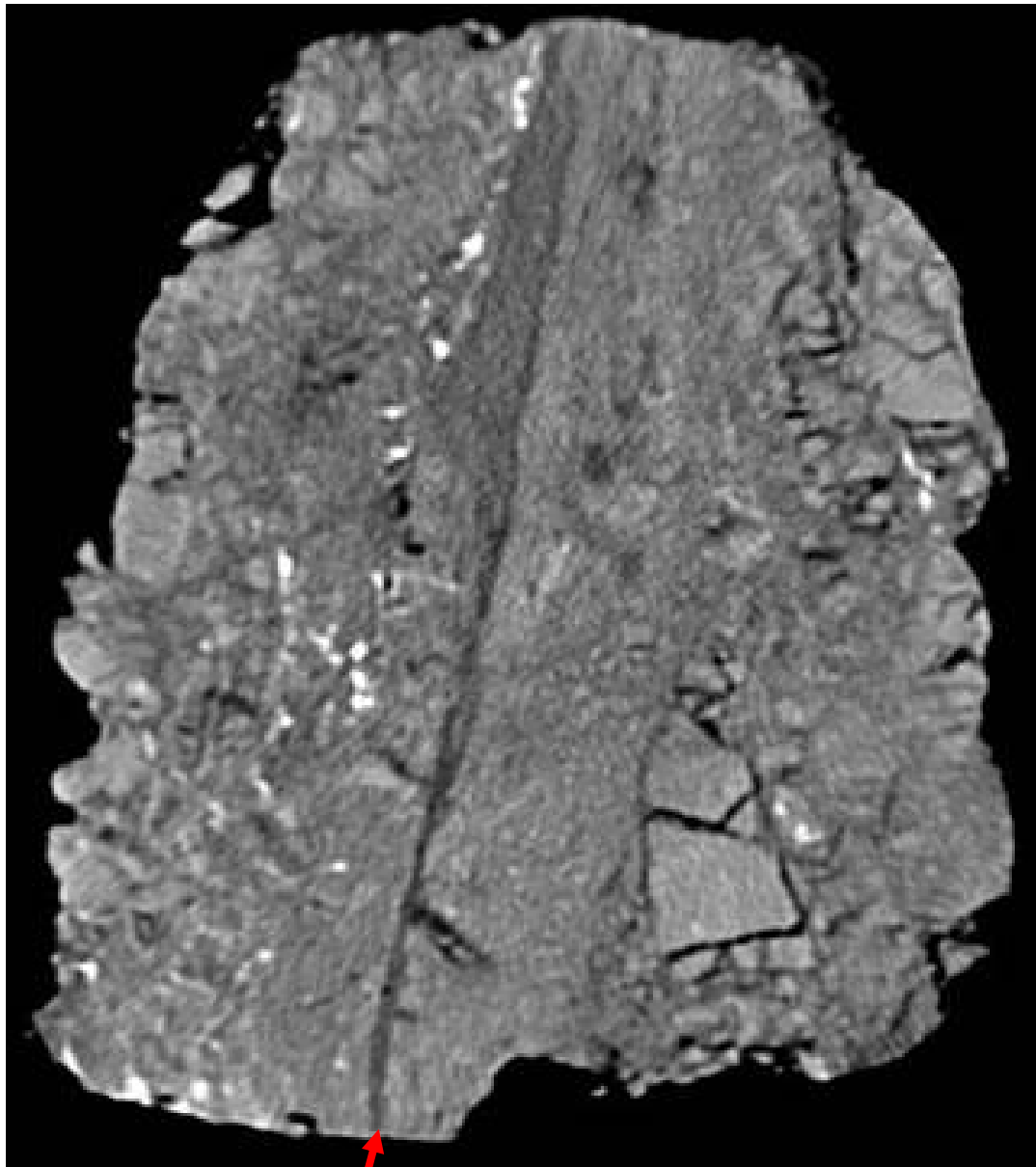


A 2mm thick fault gouge is observed along the main fault surface.





Inner structure of the fault rock was analyzed by X-ray CT.

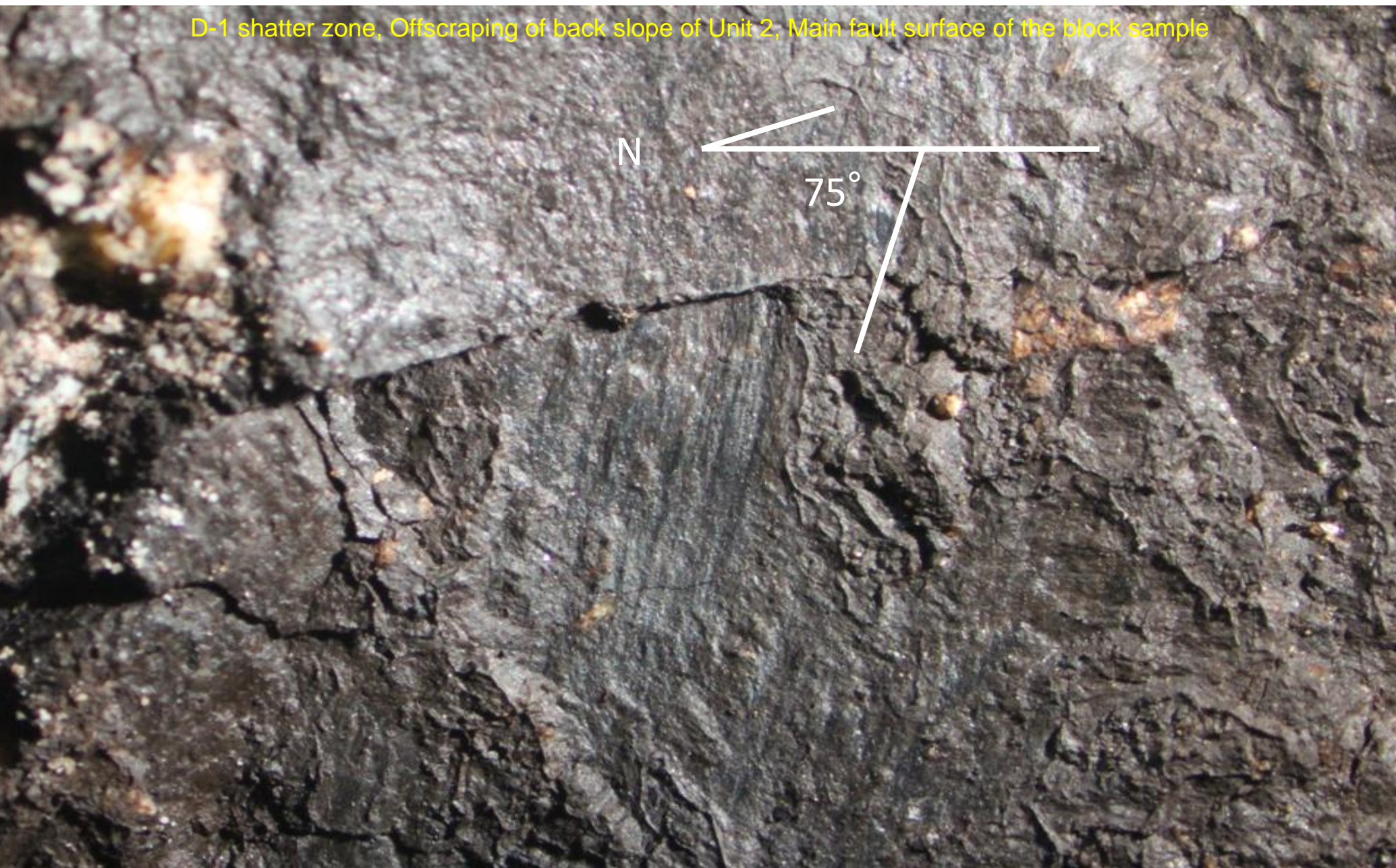


Vertical cross-section

A thin and long fault gouge is observed along the main fault surface (Last slip).

Main fault surface

50 mm



Viewing from the west side of main fault surface on the footwall. Slickenline at a high-angle (75°) is observed.

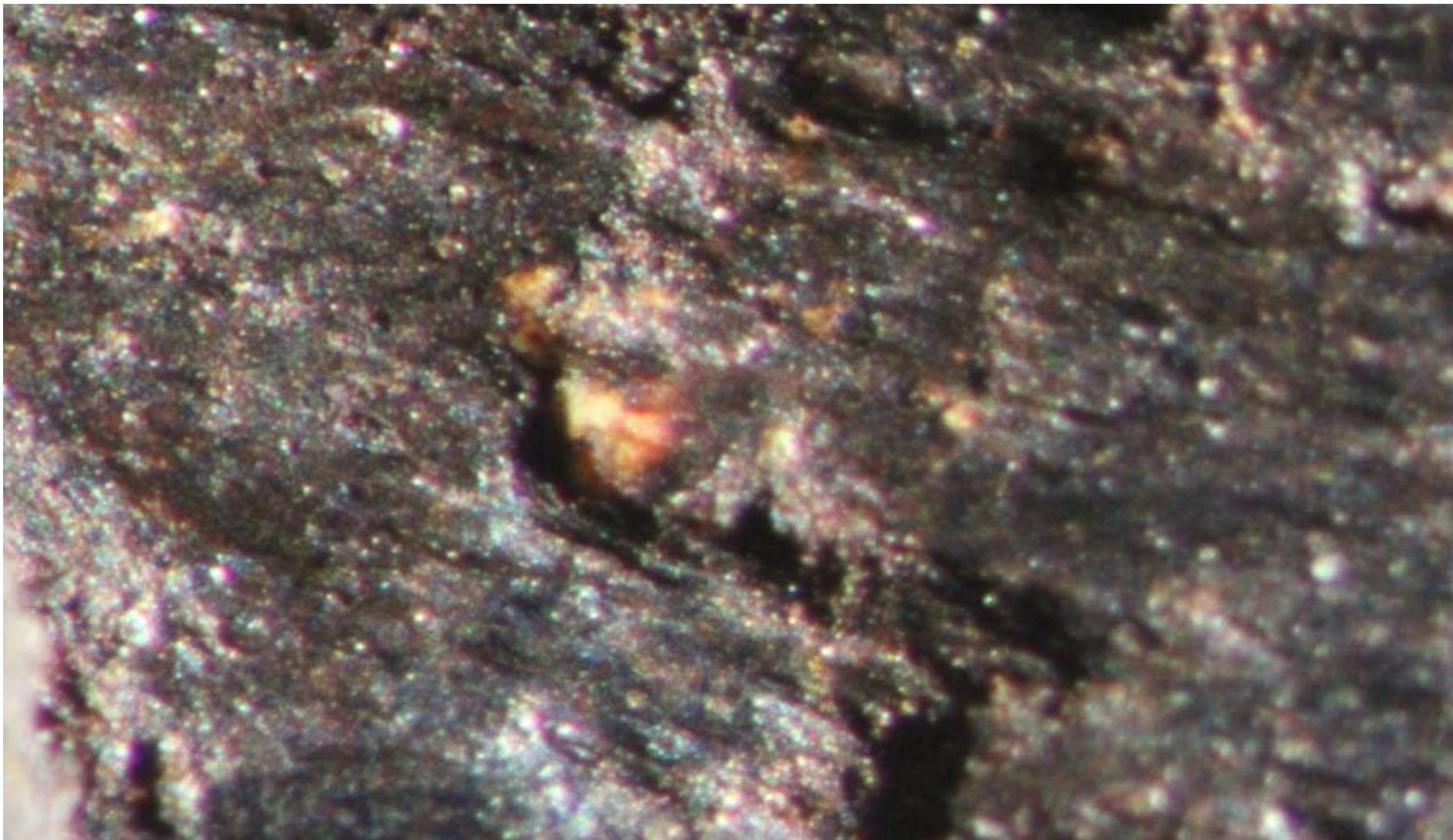
N
←

Upper side



Viewing from the west side of main fault surface on the footwall. Slickenline at a high-angle is observed.

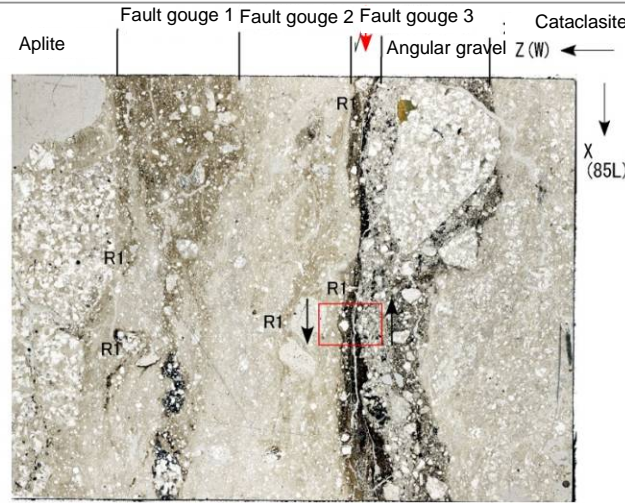
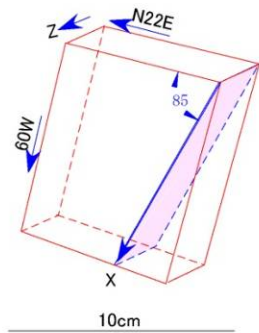
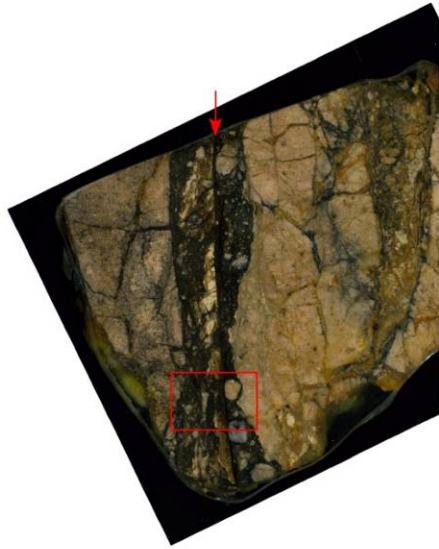
Upper side ←



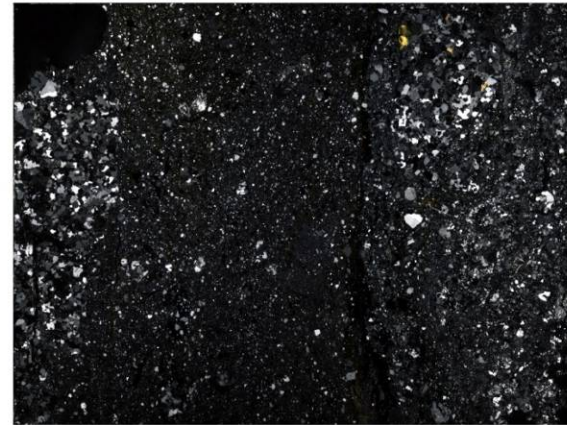
N

Viewing from the west side of main fault surface on the footwall.

D-1 shatter zone, Unscraping of back slope of Unit 2, Thin section (direction of the slickenline)
(without auxiliary line of composite surface structures)



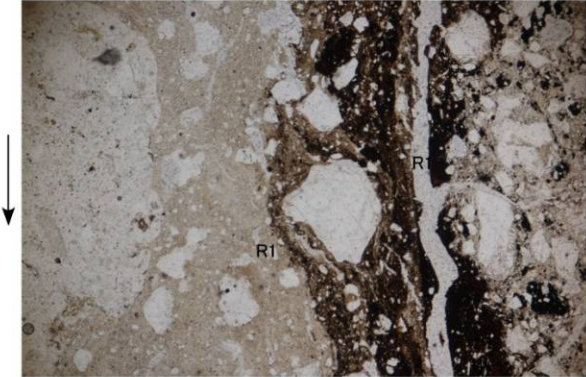
Parallel nicols



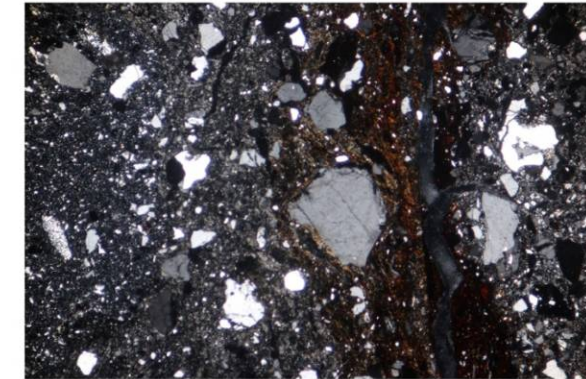
Crossed nicols

1cm

Area within red frame is enlarged



Parallel nicols



Crossed nicols

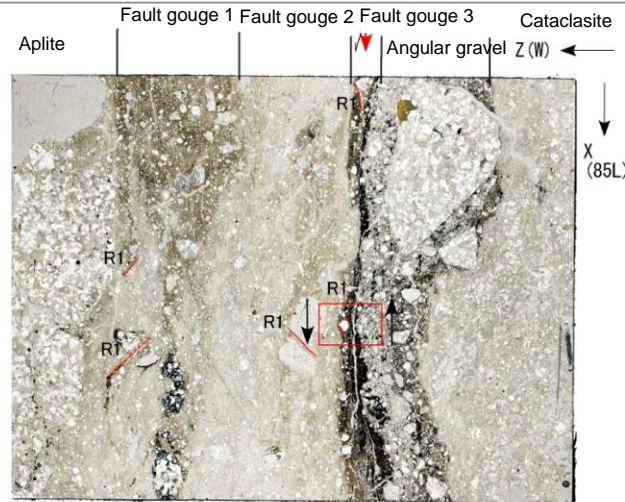
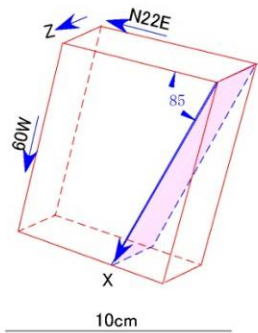
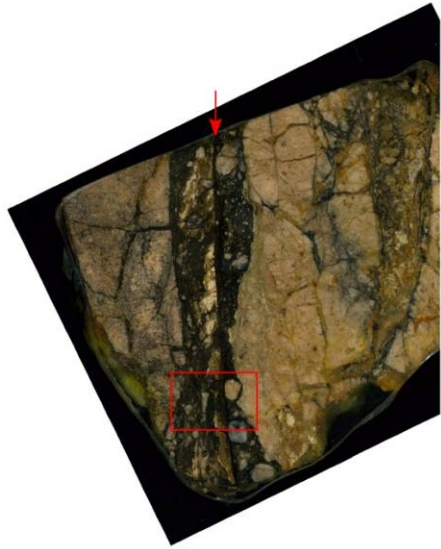
1mm

- Aplite
Consists of quartz, potassium feldspar, and plagioclase
- Fault gouge 1
Consists of the brown-gray matrix of fine grain, as well as quartz, feldspar, and cataclasite fragments and that are sub-angular or semi-circular gravels with diameters of 0.01 mm to 6mm. Contains lots of clay minerals. The displacement sense of reverse fault and left-lateral slip can be recognized from R1.
- Fault gouge 2
Consists of the brown-gray matrix of fine grain, as well as quartz, feldspar, and cataclasite fragments and that are semi-circular or sub-angular gravels with diameters of 0.01 mm to 2mm. Contains lots of clay minerals. The displacement sense of normal fault and right-lateral slip can be recognized from R1.
- Fault gouge 3 (last slip)
Consists of the brown matrix of fine grain, as well as quartz, feldspar, and cataclasite fragments and that are semi-circular or sub-angular gravels with diameters of 0.01 mm to 1mm. Contains lots of clay minerals. The displacement sense of normal fault and right-lateral slip can be recognized from R1.
- Cataclasite
Consists of quartz, potassium feldspar, plagioclase, muscovite, and calcite.

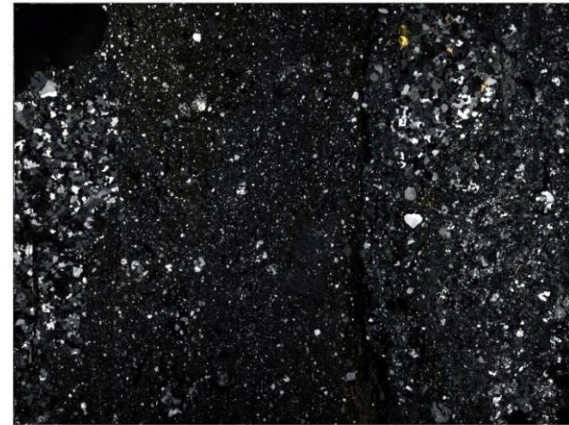
D-1 southern slope of Unit 2 direction of XZ(85L)

The displacement sense of normal fault was observed in the thin section along the slickenline of the last slip surface.

D-1 shatter zone, Offscrapping of back slope of Unit 2, Thin section (direction of the slickenline) (with auxiliary line of composite surface structures)



Parallel nicols

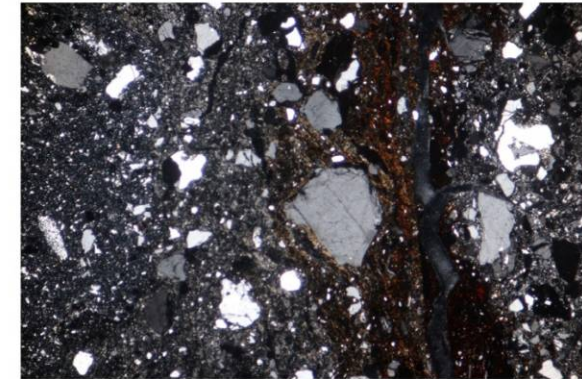


Crossed nicols

Area within red frame is enlarged



Parallel nicols



Crossed nicols

- Aplite
Consists of quartz, potassium feldspar, and plagioclase
- Fault gouge 1
Consists of the brown-gray matrix of fine grain, as well as quartz, feldspar, and cataclasite fragments and that are sub-angular or semi-circular gravels with diameters of 0.01 mm to 6mm. Contains lots of clay minerals. The displacement sense of reverse fault and left-lateral slip can be recognized from R1.
- Fault gouge 2
Consists of the brown-gray matrix of fine grain, as well as quartz, feldspar, and cataclasite fragments and that are semi-circular or sub-angular gravels with diameters of 0.01 mm to 2mm. Contains lots of clay minerals. The displacement sense of normal fault and right-lateral slip can be recognized from R1.
- Fault gouge 3 (last slip)
Consists of the brown matrix of fine grain, as well as quartz, feldspar, and cataclasite fragments and that are semi-circular or sub-angular gravels with diameters of 0.01 mm to 1mm. Contains lots of clay minerals. The displacement sense of normal fault and right-lateral slip can be recognized from R1.
- Cataclasite
Consists of quartz, potassium feldspar, muscovite, and calcite.

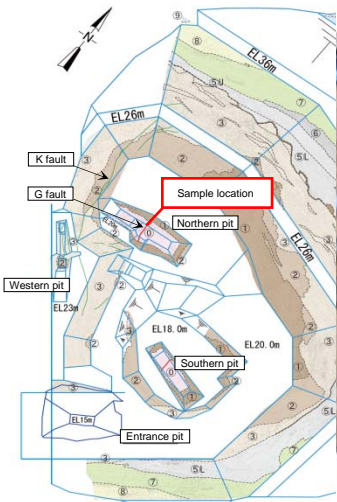
D-1 southern slope of Unit 2 direction of XZ(85L)

The displacement sense of normal fault was observed in the thin section along the slickenline of the last slip surface.

【Displacement sense of G fault】

Survey location : D-1 trench

G fault, D-1 trench, Block sample location



Northern wall surface



Eastern wall surface



Bottom surface



Southern wall surface

The displacement sense of normal fault was observed in the thin section along the slickenline of the last slip surface.



Surface B

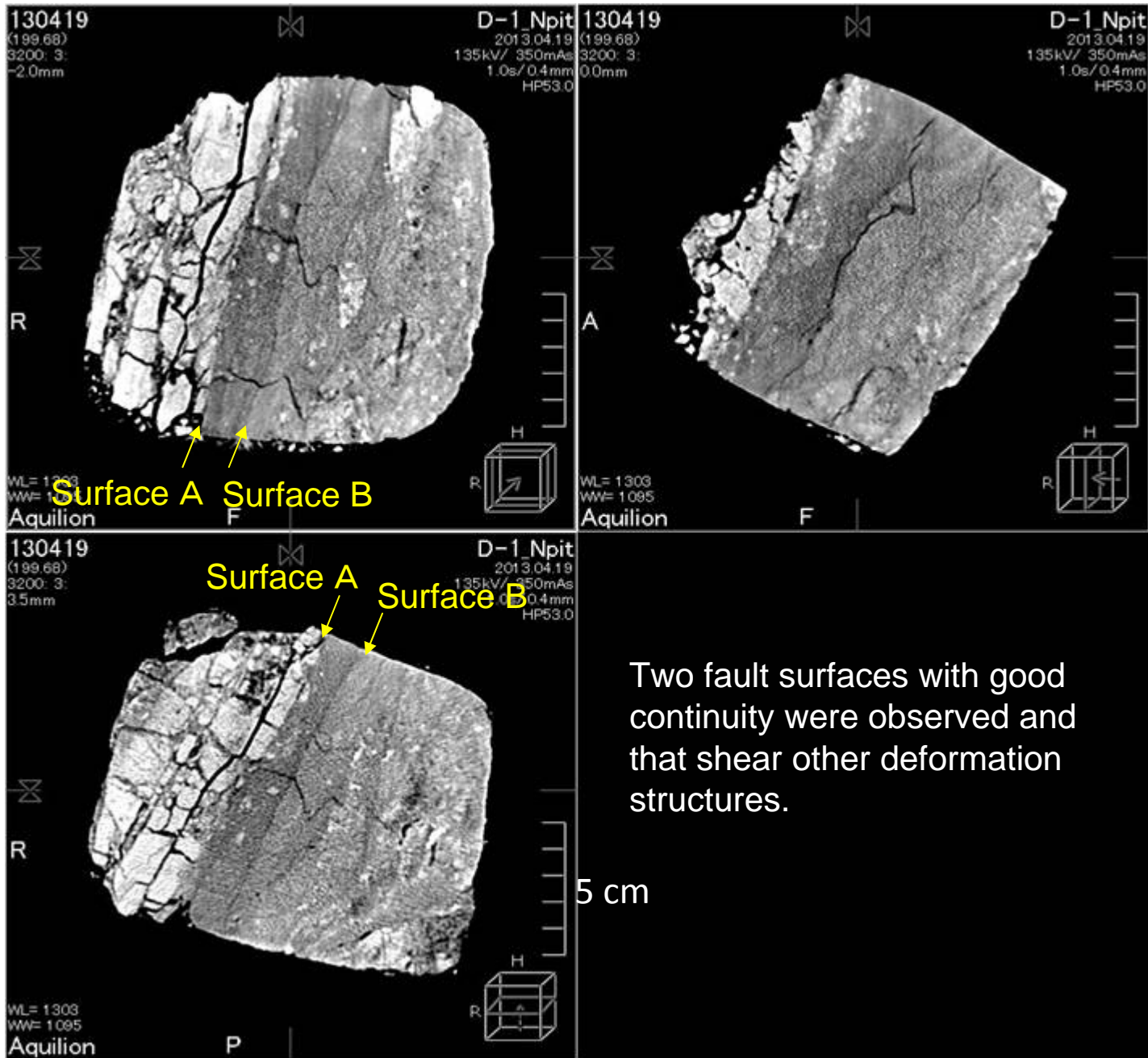
Surface A

5cm

Two fault surfaces with good continuity were observed and that shear other deformation structures.

CT scan of the block sample (G fault)





N ← G fault, D-1 trench, Northern pit, Block sample from D-1 shatter zone: Slickenline on the surface A



Looking from west side to east side. View of the footwall surface (surface A) with westerly dip. Slickenlines at a high-angle were recognized. 1 mm

N ←

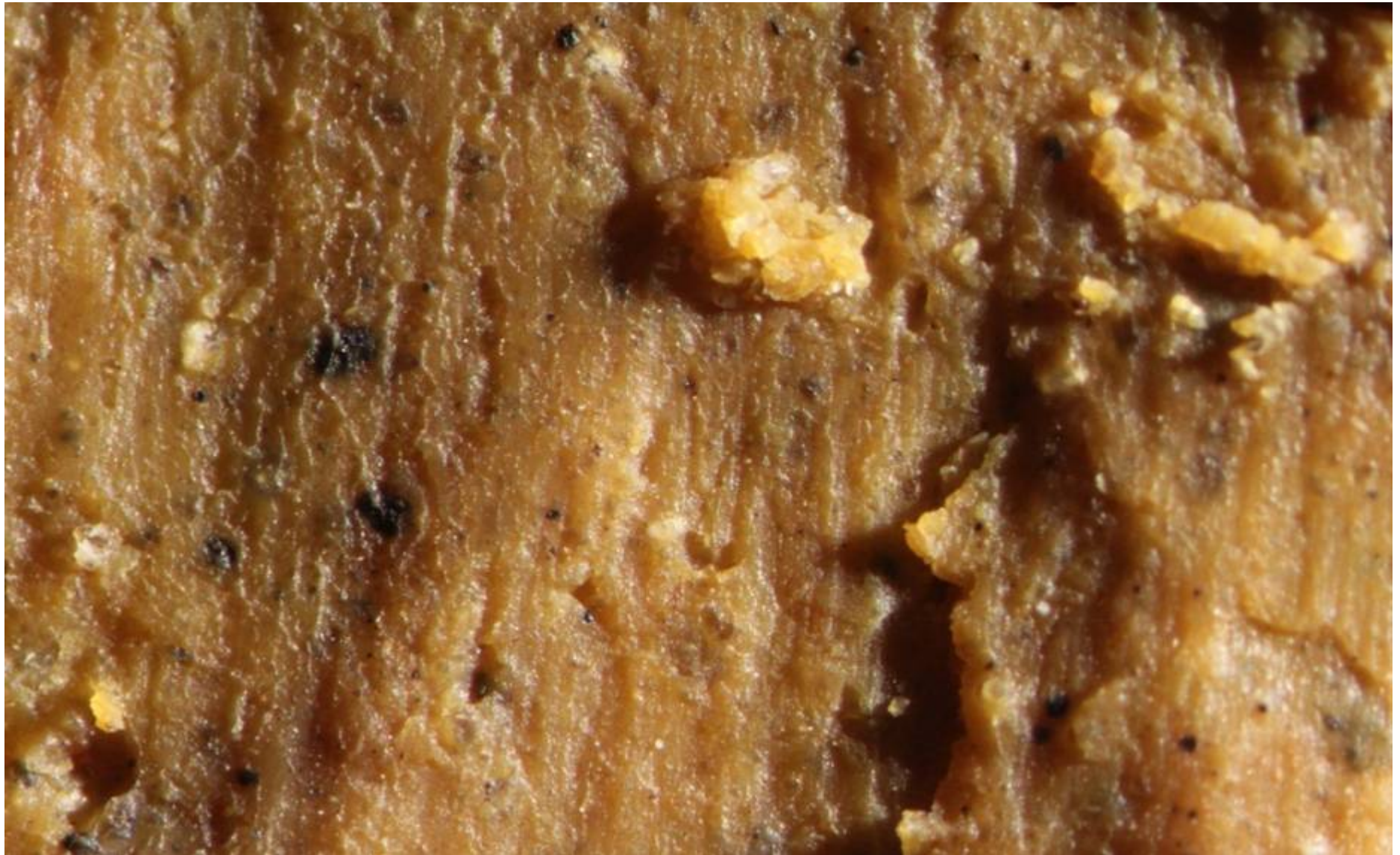
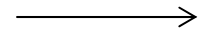
D-1 trench, Northern pit, Block sample from D-1 shatter zone: Slickenline on the surface A



Looking from west side to east side. View of the footwall surface (surface A) with westerly dip. Slickenlines at a high-angle and small dimples were recognized.



1 mm

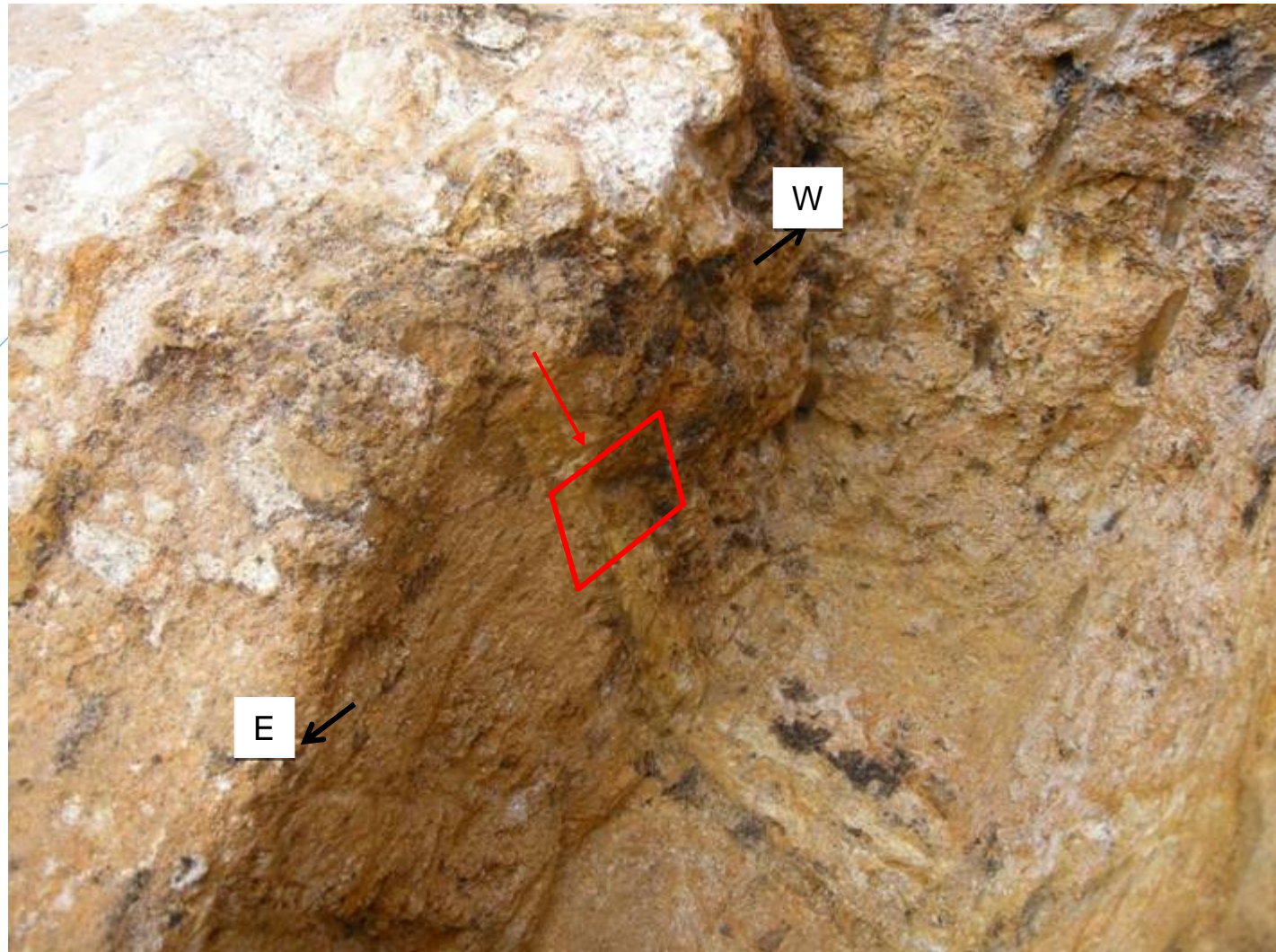
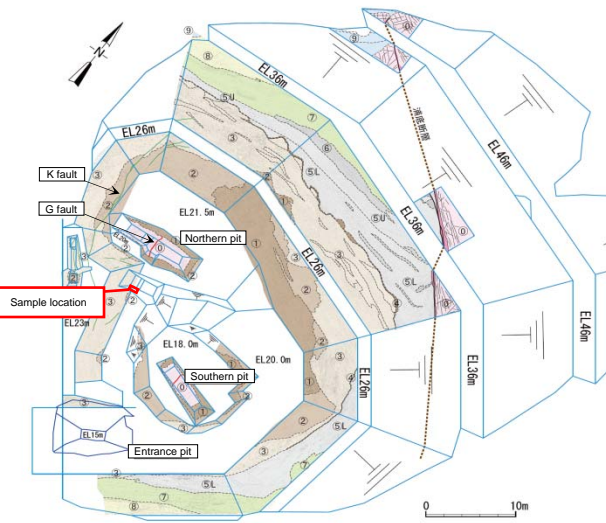


Looking from west side to east side. View of the footwall surface (surface B) with westerly dip. Slickenlines at a high-angle and small dimples were recognized.



1mm

G fault, D-1 trench, Outcrop

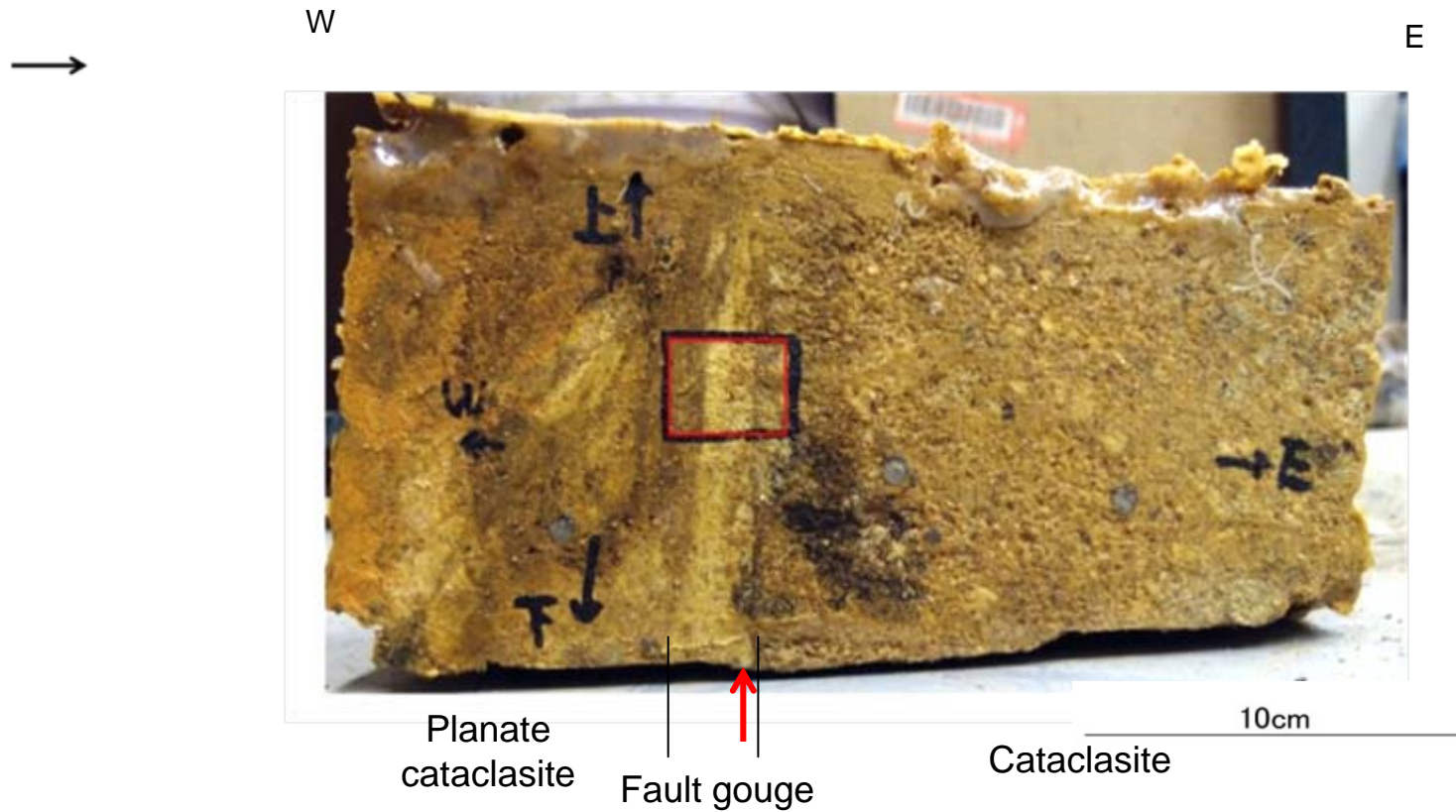


From the hanging side (western side), G fault consists of planate cataclasite, fault gouge, and cataclasite. The fault gouge linearly shears whole of the outcrop, and its footwall side has the continuous rectilinear shape.

Photograph of sample location

The last slip surface shears whole of the outcrop. That surface is located at the softest portion and has the most rectilinear shape.

G fault, D-1 trench, Polished section



From the hanging side (western side), G fault consists of planate cataclasite, fault gouge, and cataclasite. The fault gouge linearly shears whole of the outcrop, and its footwall side has the continuous rectilinear shape.

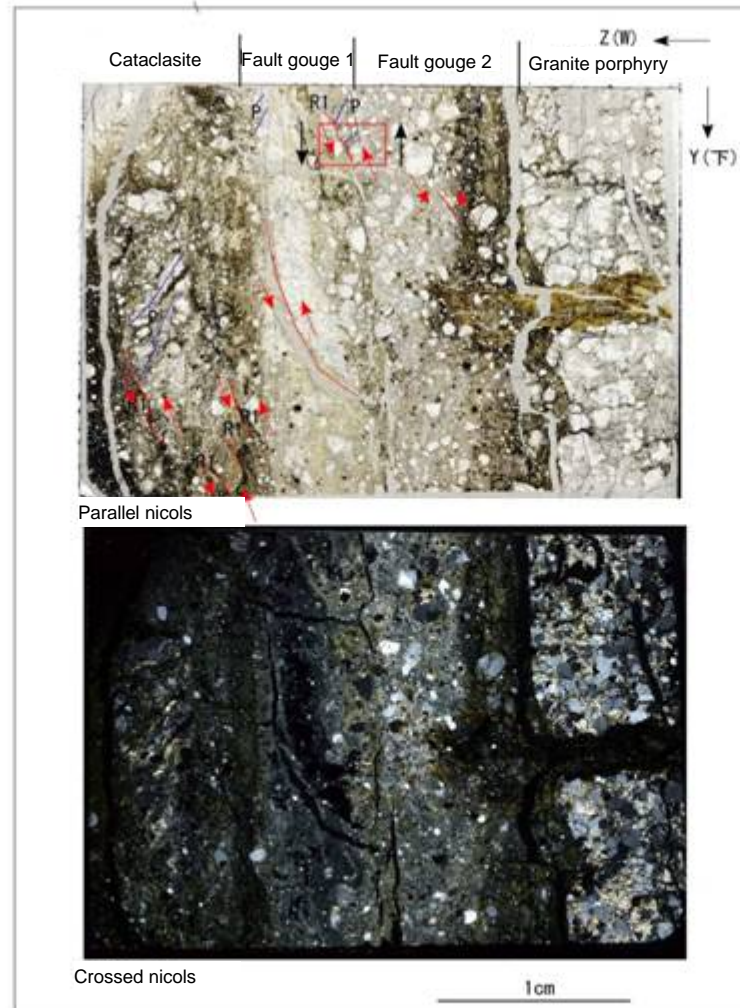
The last slip surface shears whole of the polished section. That surface is located at the softest portion and has the most rectilinear shape.

G fault, D-1 trench, Thin section (Vertical component)

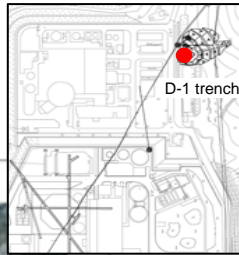
D-1 trench, direction of YZ



10cm



Area within red frame is enlarged



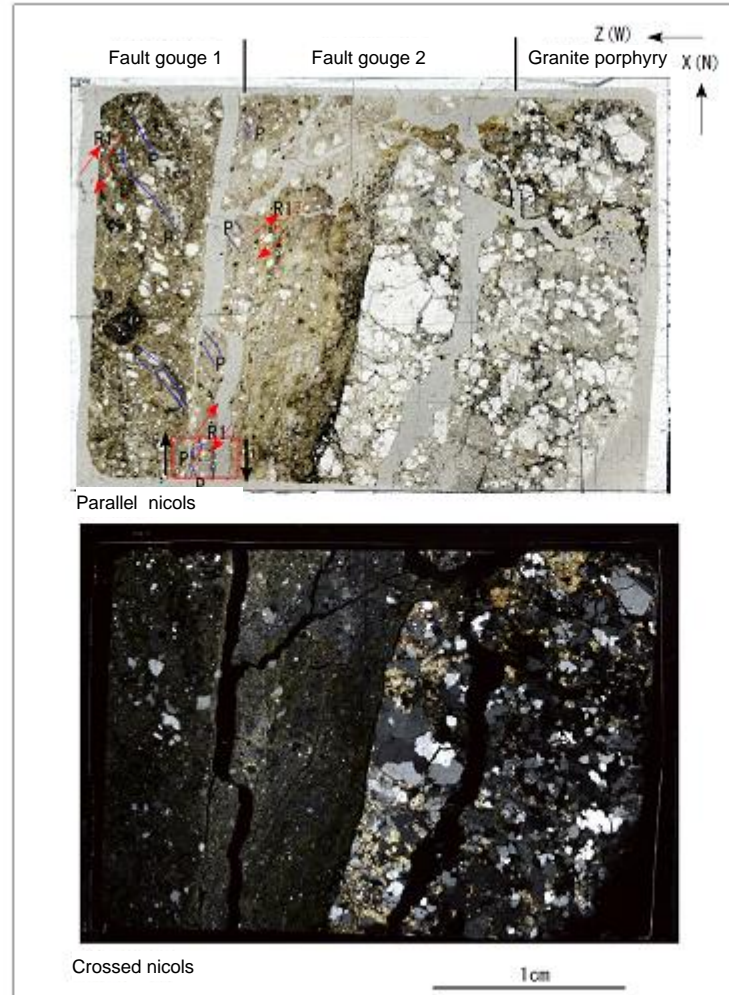
- Cataclasite
Consists of the brown-gray matrix of fine grain, as well as quartz, feldspar, and cataclasite fragments and that are sub-angular or semi-circular gravels with diameters of 0.1mm to 3mm. The matrix contains few clay minerals. The displacement sense of normal fault can be recognized from R1 and P.
- Fault gouge 1 (last slip)
Consists of the brown-gray matrix of fine grain, as well as quartz, feldspar, and cataclasite fragments and that are semi-circular or sub-angular gravels with diameters of 0.1mm to 10mm. The matrix contains lots of clay minerals. The displacement sense of normal fault can be recognized from R1 and P.
- Fault gouge 2
Consists of the brown-gray matrix of fine grain, as well as quartz, feldspar, and cataclasite fragments and that are semi-circular or sub-angular gravels with diameters of 0.1mm to 2mm. The matrix contains lots of clay minerals. The displacement sense of normal fault can be recognized from R1 and P.
- Granite porphyry
Consists of granite porphyry, quartz, and feldspar fragments with diameters of 0.1mm to 2mm.

G fault, D-1 trench, Thin section (Horizontal component)

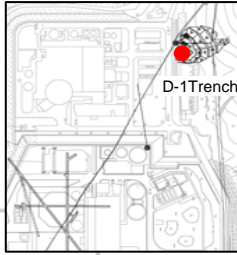
D-1 trench, direction of XZ



10cm



Area within red frame is enlarged

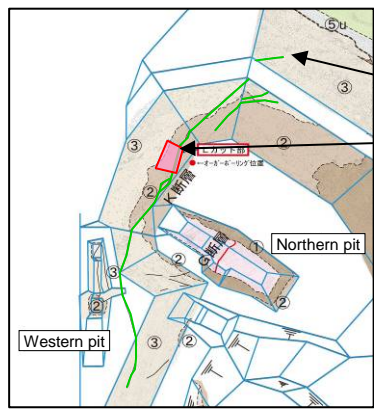


- Fault gouge 1
Consists of the brown-gray matrix of fine grain, as well as quartz, feldspar, and cataclasite fragments and that are sub-angular or semi-circular gravels with diameters of 0.1mm to 3mm. The matrix contains lots of clay minerals. The displacement sense of right-lateral slip can be recognized from R1 and P.
- Fault gouge 2 (last slip)
Consists of the brown-gray matrix of fine grain, as well as quartz, feldspar, and cataclasite fragments and that are semi-circular or sub-angular gravels with diameters of 0.1mm to 2mm. The matrix contains lots of clay minerals. The displacement sense of right-lateral slip can be recognized from R1 and P.
- Granite porphyry
Consists of granite porphyry, quartz, and feldspar fragments with diameters of 0.1mm to 2mm.

【Displacement sense of K fault】

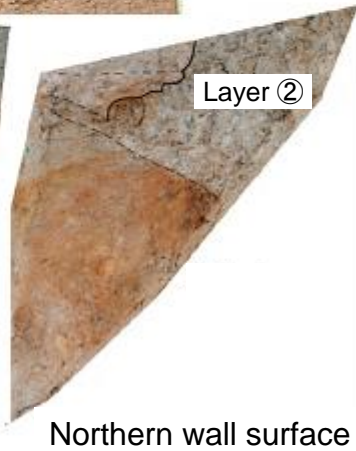
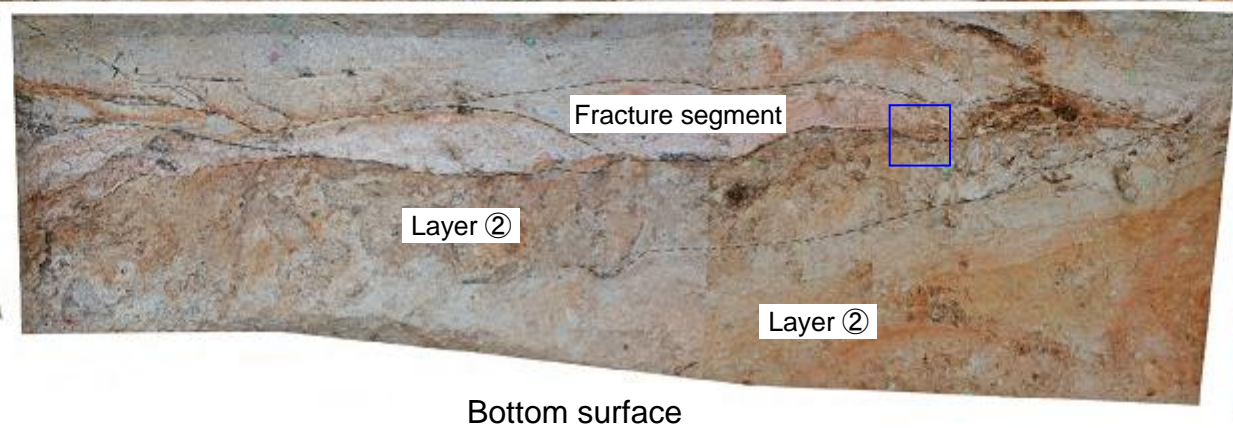
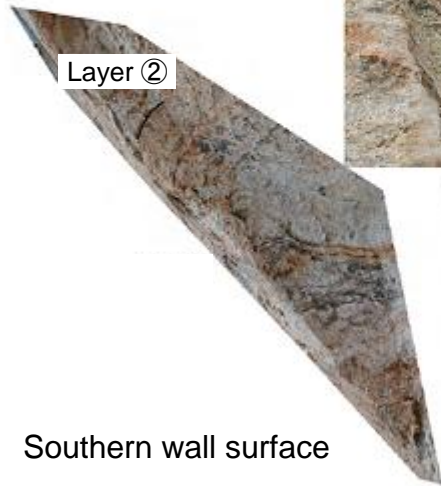
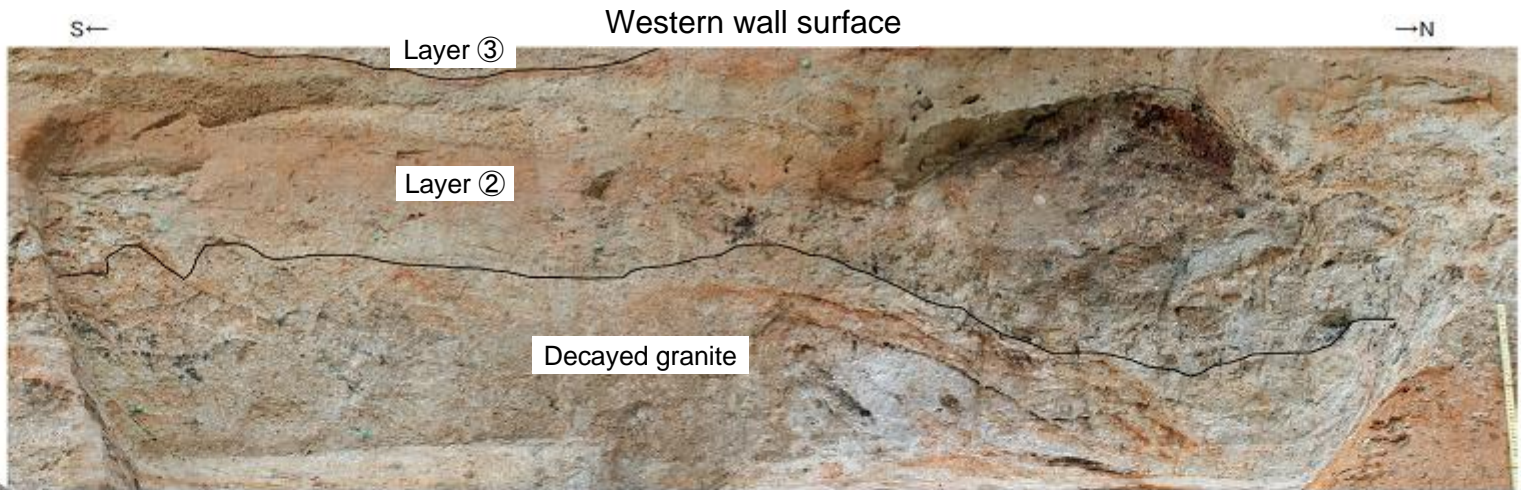
Survey location : D-1 trench L-cut pit

K fault, D-1 trench L-cut pit, Outcrop



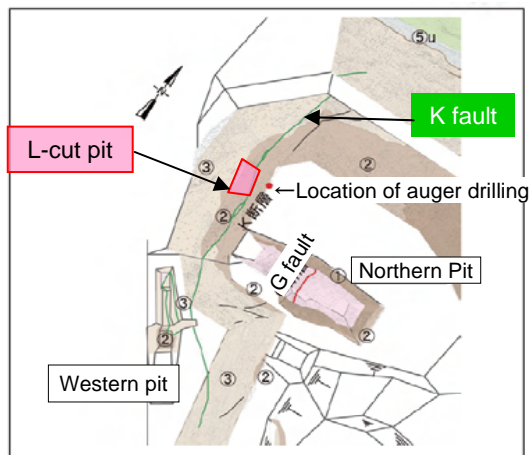
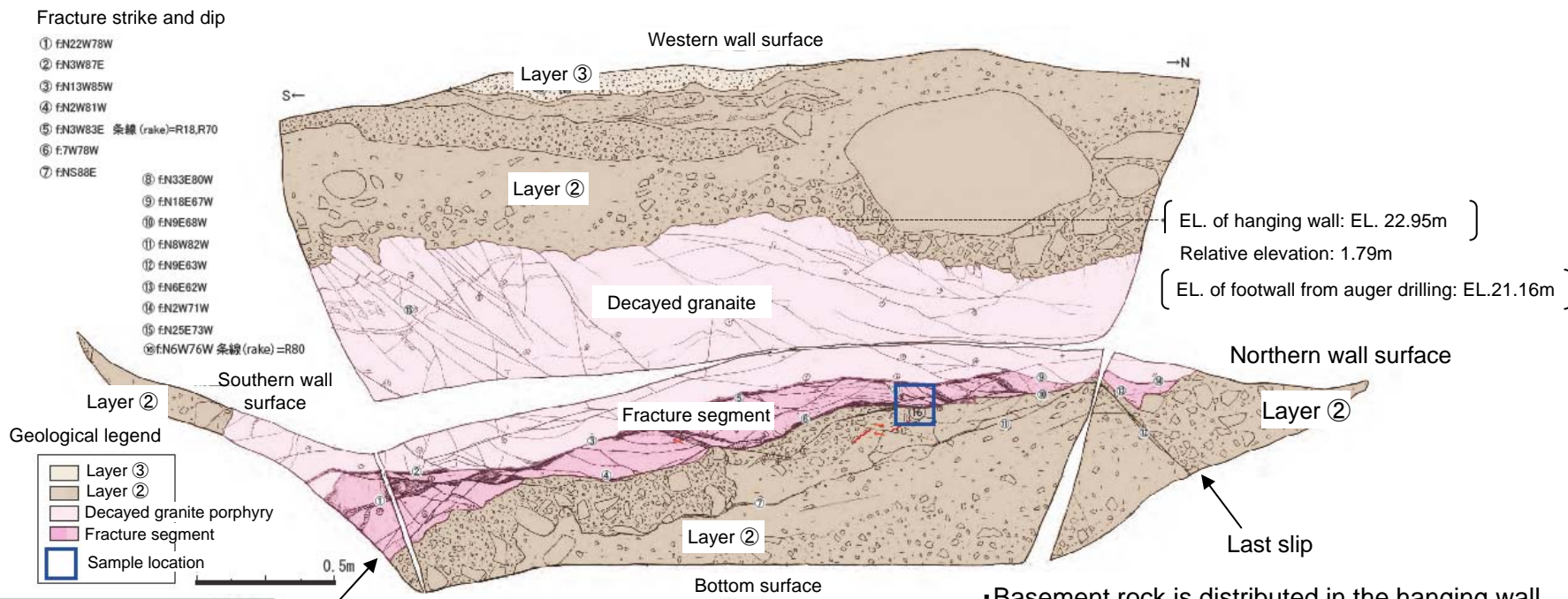
K fault

L-cut pit

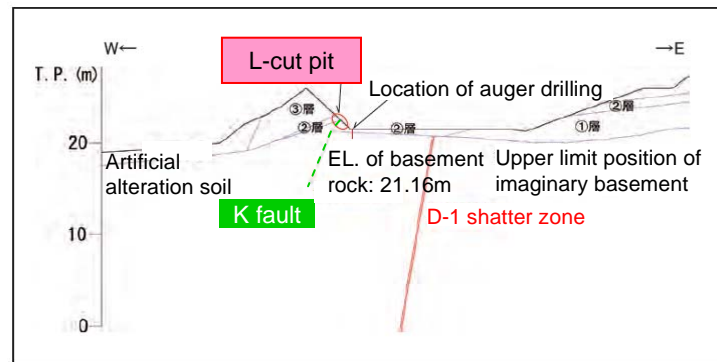


The last slip surface shears whole of the outcrop. That surface is located at the softest portion and has the most rectilinear shape.

K fault, D-1 trench L-cut pit, Sample location



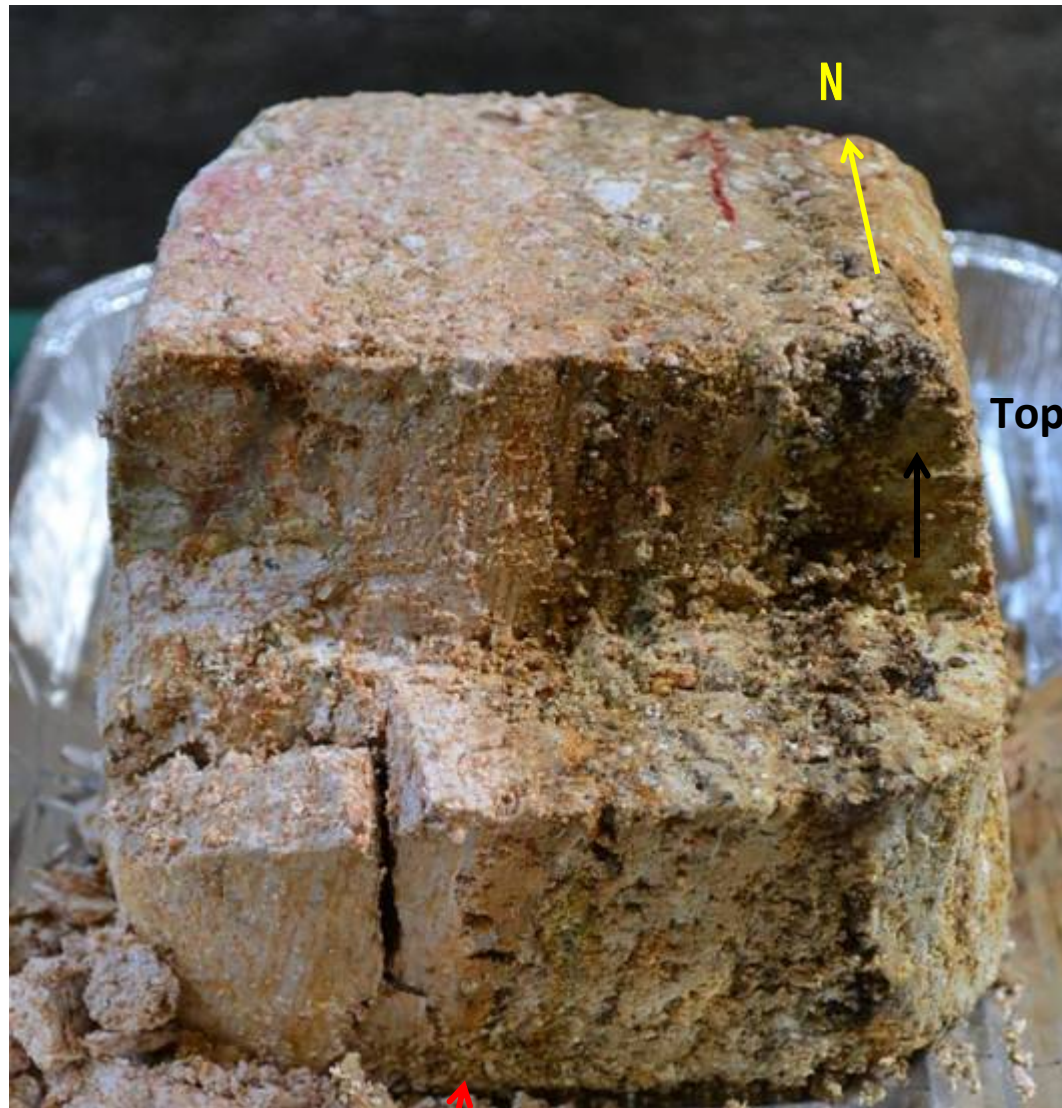
Plain view



Cross-section view

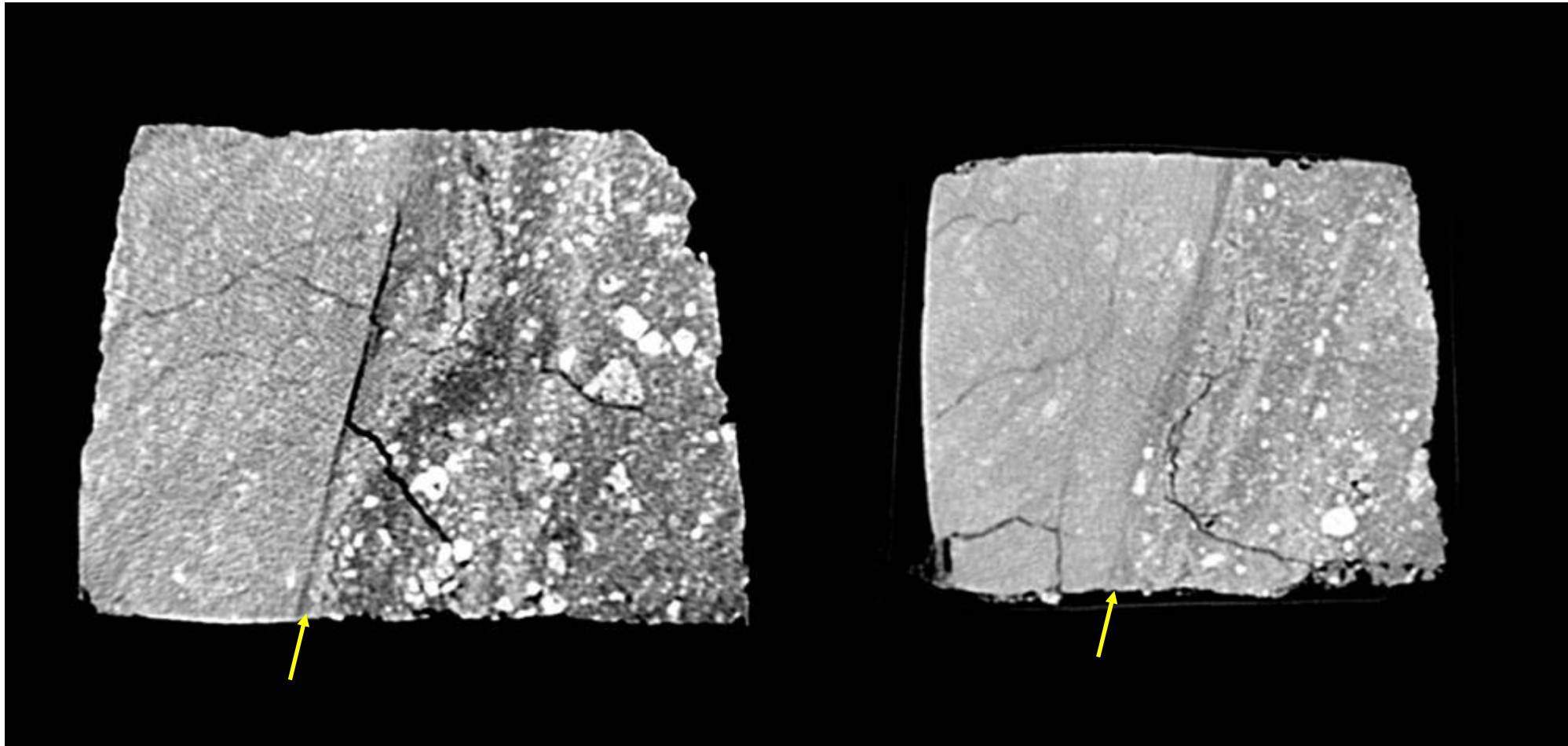
- Basement rock is distributed in the hanging wall of the shear plane, deposit (Layer ②) is distributed in the footwall.
- In the hanging wall above a shear plane, 10-30cm width fracture segment is distributed. In the deposit (Layer ②), fracture and shear structure is developing along the line of a boundary plane with the basement. A linear fault gouge is not recognized. The R1 shear with a few centimeters displacement finely slips the shear planes.
- At the R1 shear in the fracture segment and the deposit (Layer ②), right-lateral slips are observed.
- The relative elevation is 1.79m, that is calculated from the upper limit surface of the hanging wall and auger boring close to the footwall.

Fracture segment ⑤ is not a last slip because it has slickenlines with attitude in two directions.



Last slip N6W76W

50 mm

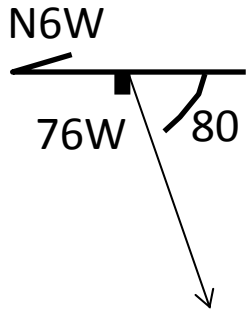


50 mm

A fault surface with good continuity was observed and that shears other deformation structures.

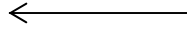
Fault surface photo from west side

N6W

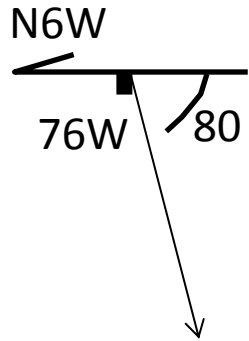


Slikenlines were observed along the main fault surface.

N6W



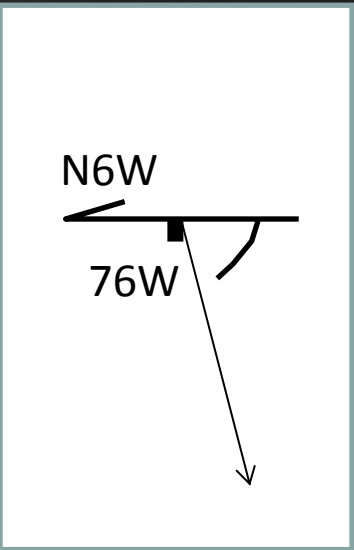
Fault surface photo from west side



High-angle slickenlines were observed on the main fault surface.

1mm

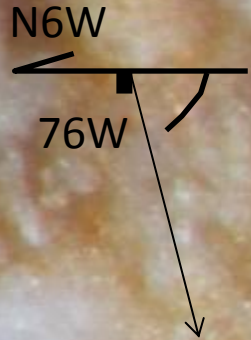
L-cut trench, K fault, Viewing from west side to east side of the footwall of the last slip



High-angle slickenlines were observed on the main fault surface.

1mm

L-cut trench, K fault, Viewing from west side to east side of the footwall of the last slip



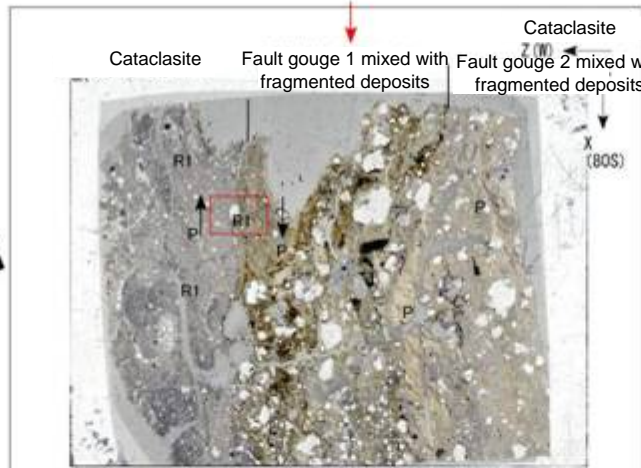
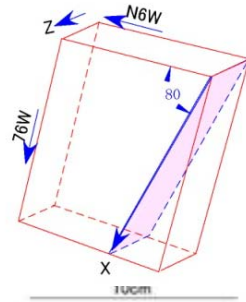
High-angle slickenlines and uneven surface were observed on the main fault surface.



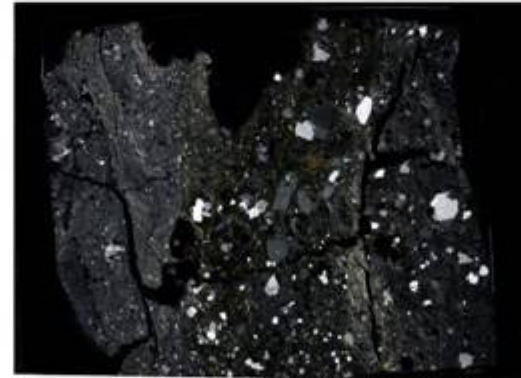
K fault, D-1 trench L-cut pit, Thin section (direction of the slickenline) (without auxiliary line of composite surface structures)



10cm



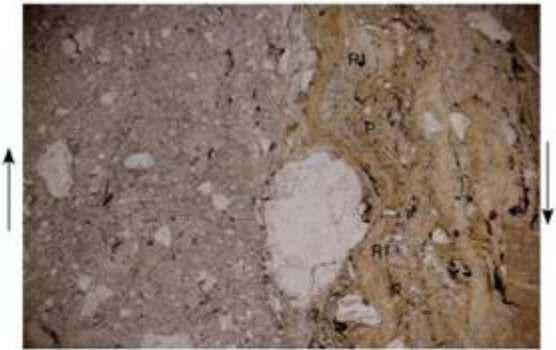
Parallel nicols



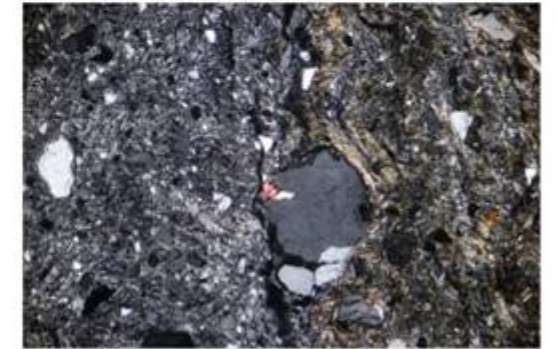
Crossed nicols

1cm

Area within red frame is enlarged



Parallel nicols



Crossed nicols

1mm

- Cataclasite
Consists of the gray matrix of fine grain, as well as quartz, feldspar, and cataclasite fragments and that are semi-circular or sub-angular gravels with diameters of 0.01 mm to 3mm. Contains some clay minerals. The displacement sense of reverse fault and right-lateral slip can be recognized from R1 and P.
- Fault gouge 1 mixed with fragmented deposits (last slip)
Consists of the brown-gray matrix of fine grain, as well as quartz, plagioclase, potassium feldspar, biotite, and cataclasite fragments and that are angular or sub-angular gravels with diameters of 0.01 mm to 3mm. The Fragments are fresh and angular originated from deposits. Contains lots of clay minerals. The displacement sense of reverse fault and right-lateral slip can be recognized from R1 and P.
- Fault gouge 2 mixed with fragmented deposits
Consists of the brown-gray matrix of fine grain, as well as quartz, plagioclase, potassium feldspar, biotite, and cataclasite fragments and that are sub-angular gravels with diameters of 0.01 mm to 2mm. The Fragments are fresh and angular originated from deposits. Contains lots of clay minerals. The displacement sense of reverse fault and right-lateral slip can be recognized from P.

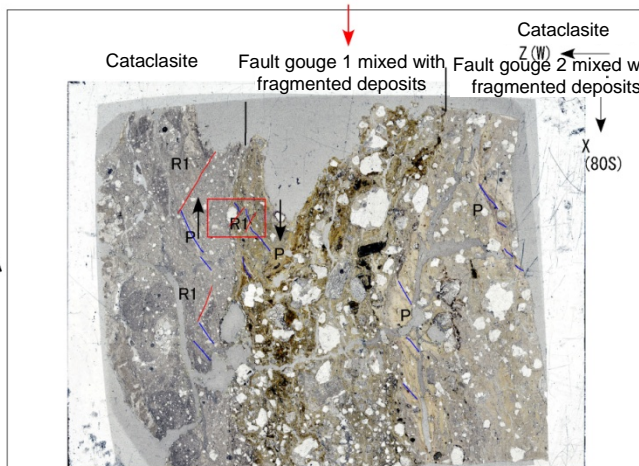
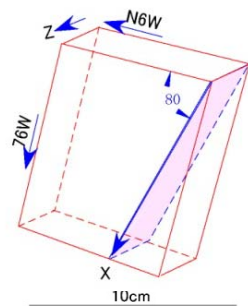
The displacement sense of reverse fault was observed in the thin section along the line of the slickenline.

K fault L-cut pit 80R

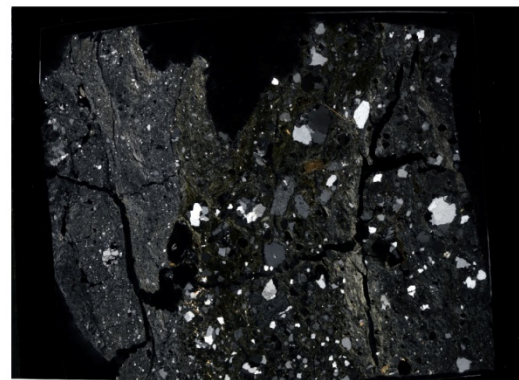
K fault, D-1 trench L-cut pit, Thin section (direction of the slickenline) (with auxiliary line of composite surface structures)



10cm



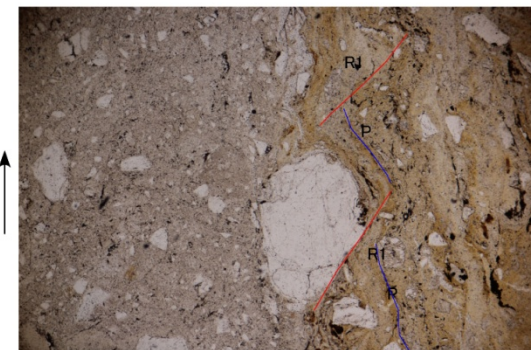
Parallel nicols



Crossed nicols

1cm

Area within red frame is enlarged



Parallel nicols



Crossed nicols

1mm

- Cataclasite
Consists of the gray matrix of fine grain, as well as quartz, feldspar, and cataclasite fragments and that are semi-circular or sub-angular gravels with diameters of 0.01 mm to 3mm. Contains some clay minerals. The displacement sense of reverse fault and right-lateral slip can be recognized from R1 and P.
- Fault gouge 1 mixed with fragmented deposits (last slip)
Consists of the brown-gray matrix of fine grain, as well as quartz, plagioclase, potassium feldspar, biotite, and cataclasite fragments and that are angular or sub-angular gravels with diameters of 0.01 mm to 3mm. The Fragments are fresh and angular originated from deposits. Contains lots of clay minerals. The displacement sense of reverse fault and right-lateral slip can be recognized from R1 and P.
- Fault gouge 2 mixed with fragmented deposits
Consists of the brown-gray matrix of fine grain, as well as quartz, plagioclase, potassium feldspar, biotite, and cataclasite fragments and that are sub-angular gravels with diameters of 0.01 mm to 2mm. The Fragments are fresh and angular originated from deposits. Contains lots of clay minerals. The displacement sense of reverse fault and right-lateral slip can be recognized from P.

The displacement sense of reverse fault was observed in the thin section along the line of the slickenline.

K fault L-cut pit 80R