

FROM 2D TO 3D CHEMICAL ANALYSIS: A μ -XRF, EDS AND EBSD STUDY OF THE GUJBA CB CHONDRITE. L0' Dgtrk³, . " C0' M0' r gn³. " D0' M0' J cpug³. " V0' Ucn g³. " F0' I qtc³. " N0' Rrcuug³. " T0' Vci r³. " W0' Y crf uej r³ gt³ cpf " T0' J 0' Lqpgu⁴ 0' ³Dtwngt " P cpq " I o dJ . " Uej y ct| uej kf utcuug " 34. " 346: ; " Dgtrk. " I gto cp{ 0' ⁴F gr ctvo gpv'qh'Gctvj 'cpf "Rmpgvt{ "Uelgpegu "Wpklgtuk{ "qhl'P gy "O gzleq. "Crdws wgtv wv. "P O : 9353. "WUC0" , Eqpvcev'Lepe'Dgti j qm "o ckl gp'pco g<Dgtrk+. "Go ckr<lcpe0lgti j qm B dtwngt/pcpqf g0" "

Introduction: " O gcn' r ctvrgu " cpf " ukrcvq " ej qp/ f twrgu "lp "ED" ej qpf tkgu "ctg" uwi i guvgf "vq" j cxg "hqt" o gf " htqo "c" xcr qt/ o gm' r nwo g' i gpgtcvqf "d{ "c" o clqt "ko r cev" dgw ggp " r tqvr rmpgvt { "dqf lgu" } 3.4_0' Vj ku "uggo u" vq "dg" uwr r qtvgf "d{ "y j g" { qwpi " ⁴²⁹Rd/ ⁴²⁸Rd " ci gu " *c60'85" I c+ " qh' uqo g " ej qpf twrgu "lp " y q "ED" ej qpf tkgu " *I vldc " cpf " J cJ 459+ " y j lej " r quf cvg " y j g " o quv' epekp'v' ECKi' d { "c7" O c "]5_0J qy gxgt. " y j g " zkvqpeg " qh' j k j / r tguuwt " r j cugu "]6_ " y q / r j cug " o gcn' r ctvrgu "]7_ " cpf " Hg / P k U " gwgeve " vgzwtgu "]8_ " r tqxk f g " gxkf gpeg " hqt " c " ugeqpf ct { " ko r cev " gxgpv' y cv' ecwugf " uki plklecpv' tgi gcvkpi " cpf " lqvgtcevkqp " dgw ggp " r tggzkvki " o gcn' r ctvrgu " cpf " cp " kpxcf kpi " ukrcvq / tlej " ko r cev' o gm' o cvtkz0" "

J gtg. " y g " r tguqpv' 5F " ej go lecn' f cvc " qh' I vldc " qdvclopf " d { " o letq / Z / tc { " hmwqtguegpeg " *U / ZTH+ " cpf " uecpkpi " grgevtqp " o letqueqr { " y kj " gpgti { " f kr gtukxg " Z / tc { " ur gextqo gvt { " *GF U+ " r nmu " ugtkcn' ugevkpki 0' Ugrgevgf " tgi kqpu " qh' lqvgtguv' y gtg " cmq " gzco kpgf " y kj " grgevtqp " dcemuecwt " f hhtcevkqp " *GDUF + " cpf " GF U0' Vj g " o clp " i qcn' qh' y ku " uwf { " ku " vq " wpf gtucpf " y j g " ej go lecn' cpf " r j { ulecn' lqvgtcevkpu " dgw ggp " r tggzkvki " o gcn' cpf " ko r cev' o gm' lp " I vldc " qp " y j g " Uo " / " vq " o o / uecrq0' "

Analytical details: Hki wtg " 3 " u j qy u " y j g " I vldc " EDc " o gvgqtkg " uco r r g " y j cv' y cu' or qrkuj gf " cy c { o' f wtkpi " y j g " eqwtug " qh' y ku " uwf { " hqt " 5F " ej go lecn' cpcn' uku0' J qy gxgt. " cm' y j g " f cvc " ctg " ucxgf " kp " j { r gtur gextcn' f cvdcugu " *J { r gtO cr u+ " hqt " r vgt " tg / gzco kpevkp0' k p " Vcdrg " 3. " cpcn' vlcen' f gvcku " ctg " r kvgf " hqt " y j g " y j tgg " 5F " f cvcugw' y j cv' y gtg' r tqf wegf 0Co k c ¹ " uqhy ctg " y cu' wugf " hqt " y j g " 5F " tgeqput wevkpu0' "

Table 1. Analytical details.

"	μ -XRF: Vol. 1 (Fig. 2)	μ -XRF: Vol. 2 (Fig. 3)	EDS (Fig. 4)
Xqno g "	44222' o o 5"	630' o o 5"	208' o o 5"
Nc {gtu "	58 "	5: "	43 "
Ugevkp' Tgr yj "	c36: 'Uo "	c6: 'Uo "	c6'Uo "
Vqcnf' gr yj "	708: 'o o "	30: 'o o "	: 2'Uo "
Xqzgrnk g "	54z54z36: 'Uo "	8z8z6: 'Uo "	30z30z6'Uo "
Kpntvo gpv' "	O 6' Vqtpcf q "	O 6' Vqtpcf q "	Z Hcu j ¹ 882 "
Cee0' Xqnci g "	52' hX "	52' hX "	37' hX "
Dgco 'ewtgpv' "	822' UC "	822' UC "	7' pC "
Kpr w' eqwpcvg "	c372' ner u "	c372' ner u "	c352' ner u "
Ces vkiakqp " " vto g' r' gt' ic' {gt "	: 2' o lp "	82' o lp "	: 2' o lp "
I t' kpi kpi laco r r g " r tgr' r' gt' ic' {gt "	c42' o lp "	c37' o lp "	c37' o lp "
Total time	c82' j qwtu "	c72' j qwtu "	c62' j qwtu "

Results: " " μ -XRF. " " Vj g " I vldc " uco r r g " *Hki 0'3+ y cu' cm quv' eqo r r g vgn' " o cr r gf " y kj " U / ZTH' kp " 58 " r {gtu " cpf " c " ugevkpki " f gr yj " qh' c36: " Uo " *dXqno g " 3o+0' C " 5F " tgeqput wevkqp " qh' y j g " Hg " *gf +. " P K " *tggp+ " cpf " U " * { gm yj + " f cvc " ku " u j qy p " kp " Hki 0'40' C v' r gcu v' 7 " v { r gu " qh' o gcn' r ctvrgu " ctg " r tguqpv. " y j lej " ecp " dg " ej ctcevtk' gf " d { " y j gk " P k' eqpv' p " *ny < c7 " y v . " lqvto gf kvq < c80' " y v " cpf " j k j < c: 04' y v +. " cu' y gm' cu' d { " y j g " cdwvf cpeg. " uk' g " cpf " u j cr gu " qh' uwrkf g " kpenwku pu "]4_0' "

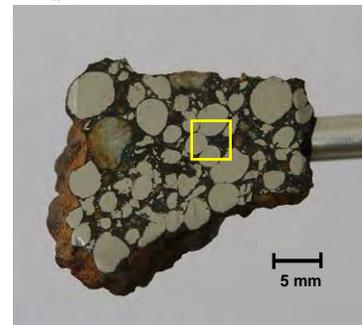


Fig. 1. Gujba sample that was used for 3D chemical analysis. The yellow box indicates the location for the 3D- μ XRF dataset "Volume 2" (shown in Fig. 3) and the 3D-EDS dataset (shown in Fig. 4).

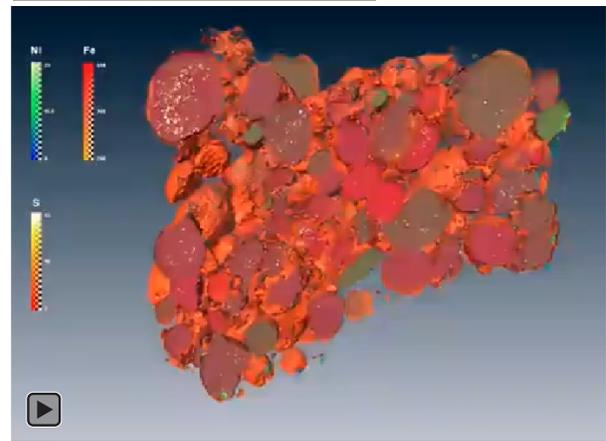


Fig. 2. 3D reconstruction (click on the image to start the movie!) of μ -XRF data (Fe: red, Ni: green, S: yellow) for the Gujba sample shown in Figure 1. Refer to the second column (μ -XRF: Vol. 1) of Table 1 for analytical details.

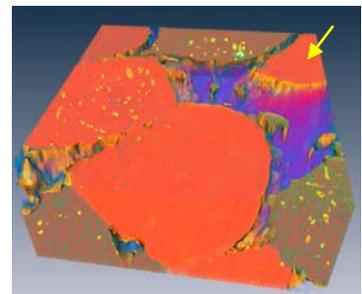


Fig. 3. 3D reconstruction of μ -XRF dataset Vol. 2 (4.82 x 4.84 x 1.78 mm) with Fe in red, Ni in green, S in yellow and Cr in blue. The location of this dataset is indicated by the yellow box in Fig. 1. Refer to the third column of Table 1 for analytical details.

Hki wtg"5"uj qy u" c"5F "tgeqputwekqp"qh"vj g"Ü/ZTH" f cvcugv"öXqno g"4ö"ht "Hg"t gf + "P k"i tggp+ "U" { gmny + " cpf "Et "dng+0C" j ki j gt "ur cvkn'tguwnkqp"ku"pggf gf "vq" tguqkrg" uwhkf g" i tckpu "cpf" qvj gt "utwewtgu"uo cmgt" vj cp" 8" Üo "kp" uk g" ö" vj ku" ku" y j gtg" GF U" eqo gu" kp0' J qy gxgt. "cp" cf xcpvci g"qh"Ü/ZTH" eqo r ctgf "vq" GF U. " ku" vj g" dgwgt" ugpukxkv" hqt" grgo gpw" y kj" cvqo le" pwo dgt "@44" *Vki0Gur gekm" "vj g"5F /ÜZTH" f cvc" hqt "O p" ctg" lpygt gukpi . "y j lej "y km'dg"uj qy p"cv'j g" eqphgt gpeg0'

EDS. "Hki wtg"6"uj qy u" vj g"5F /GF U" f cvcugv" hqt "Hg" *t gf + "cpf" "U" * { gmny +0' Vj ku" f cvcugv" qxgtrr u" y kj" vj g" wr r gt "j ch"qh"vj g"5F /ÜZTH" f cvcugv"öXqno g"4ö" *t ghgt" vq "Hki 0'5+0P qvg"vj cv'j g'o gvcn' r ctveng" qp"vj g'tki j vj cpf" ukf g" * { gmny "cttqy "kp" Hki u'0'5" cpf "6+" eqpvckpu" c" nti g" pwo dgt" qh" uwhkf g" i tckpu"uo cmgt" vj cp" 8" Üo "kp" uk g. " y j gtgcu" vj g" o gvcn' r ctveng" qp" vj g" nhlv'j cpf" ukf g" eqpvckpu" uwhkf gu" hqto kpi " cp" ctewcvglkdy n'uj cr gf" vgzwtg" *dng" cttqy u" kp" Hki 0'6+0C tqwpf "vj g" uwhkf g/ht gg" gf i gu"qh"vj ku" i tckpu. "c" nqv"qh" uwhkf gu" ctg" hqwpf "kp" vj g" lo r cev'o gm'o cvtkz "y j kg" cttqy u" kp" Hki 0'6+0'

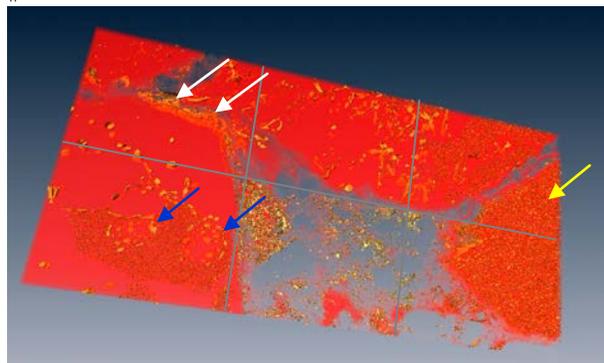


Fig. 4. 3D reconstruction of EDS data (Fe: red, S: yellow). To cover a larger area, 6 maps (3x2 – indicated by the gray lines) were put together as a mosaic for each of the 21 layers. The total size of this dataset is 3.84 mm x 1.92 mm x 80 µm. Refer to the fourth column of Table 1 for analytical details.

Combined EBSD/EDS. "Hki wtg"7"uj qy u" GF U" cpf " GDUF " f cvc. "y j lej "y gtg" ces vkt gf "uko wncpgqwu" . "hqt" cp" ctgc" eqpvckkpi " c" dctt gf " qrkxkpg" ej ppf twrg" *rghv' j cpf "ukf g+" cpf "c" o gvcn' r ctveng" *tki j vj cpf "ukf g+" y kj" ukrcvgt/tlej "ko r cev'o gm'o cvtkz "kp" dgvy ggp. "eqpvckkpi" o quvn' "qh"ej ppf twrg" hci o gpw0'kp" eqpvckkpi "vj g'uj cr g" qh"vj g" uwhkf gu. "y j lej "ctg" plegn' "tqwpf gf. "vj g" gf i g" qh" vj g" o gvcn' r ctveng" ku" pq'xgt { "uj ctr "cv'cm" dw'uj qy u" c" hki | gf" vgzwtg" *Hki 0'7c+0' Vj g" GDUF " f cvc" *Hki 0'7d+ " txxgn' vj cv' vj g" o gvcn' r ctveng" eqpvckkpi" qh' o cp { "uo cm' i tckpu" *cxgtci g" f lco vgt ϵ32" Üo +y kj "tckn' "tcpf qo " qtkgpvckkpu0'

Discussion: Qw" 5F" ej go lecn' f cvc" qh' I vldc" kmwtevg" vj g" r tgupeg" qh' c" ej go lecm" { cpf " vgzwtcm" j gvtqi gpgqu" o kzwtg" qh' o gvcn' r ctveng" C" hwt vj gt" o letqut wewtcn' kpxguki cvkqp" y km' j gm" vq" wpf gtucpf " "

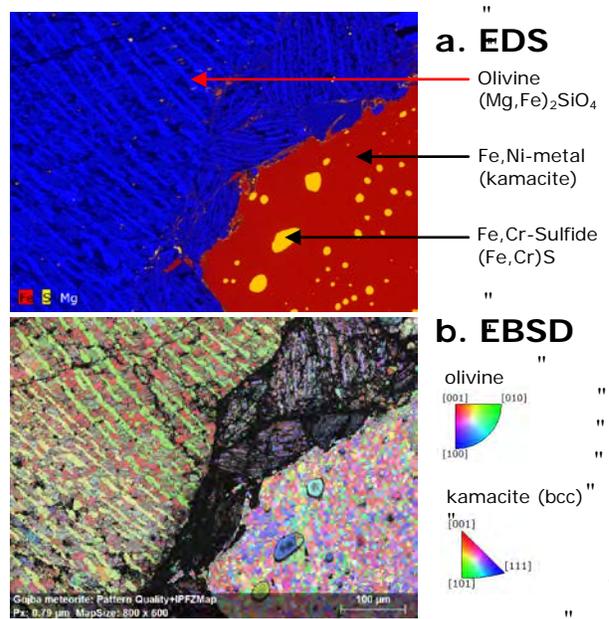


Fig. 5. a) EDS and b) EBSD (IPF-Z) data acquired simultaneously with an XFlash® 6/30 silicon-drift EDS detector and an eFlash HR EBSD detector (~70 points per second). Note the change of orientation in the olivine bars and the small grain size of the kamacite revealed by EBSD.

vj g" vj gto cn' j kvqt { " qh' vj g" f lhtgtpv' v' r gu" qh' o gvcn' r ctveng" kp" EDc" ej ppf tkgu" cpf " guvcdkuj " y j gtg" vj g { " eqwv" j cxg" hqto gf" hqo " vj g" uco g" tguqtxqk" cu" uwi i guvgf "d { "3.4_0'

Hwt vj gto qtg. "y kj "vj g"5F" ej go lecn' f cvc" qh' I vldc. " y g" ecp" dgwgt" xkwrnk g" cpf " i teur " vj g" o ci plkwf g" qh' kvgtcevkpu" dgvy ggp" r tggzkvki " o gvcn' r ctveng" cpf " vj g" kpxcf kpi " ukrcvgt/tlej " ko r cev'o gm'o cvtkz. " uvej " cu" vj g" o qdkk' cvkqp" qh' uwhkf gu" *Hki 0'6+ cpf " o gvcn' f kuqrkvki " kvq" vj g" ko r cev'o gm'o cvtkz " *Hki 0'7c+0' Vj g" ugeqpf ct { " ko r cev'gxgpv' u+r tqdcdn' " j cf " c' uki plhtcpv' ghtev' qp" vj g" ej go lecn' cpf " kvqvr le" r tqr gt vgu" qh' EDc" o gvgtkvgu0'

Additional Information: " O qxkgu" qh' vj g" 5F" tgeqputwekqp" ctg' r tqxkf gf " cvc" [j wr \langlely y Qltwrgt \(eqo_luqtxleglqf_wecvqp/vckkpi_ly_gdkpctulz/te/o_letqcpn'uku/cpf/gduf_letgo_dkpkpi/o_gcuwtgo_gpvo_gv_qf_uj_vo_n'](http://www.dlyy.com/Qtwrgt/eqo_luqtxleglqf_wecvqp/vckkpi_ly_gdkpctulz/te/o_letqcpn'uku/cpf/gduf_letgo_dkpkpi/o_gcuwtgo_gpvo_gv_qf_uj_vo_n/)

References:]3_ " Eco r dgm' C0' L0' gv' cr0' *4224+ " GCA, 66, "869/8820]4_ " Twdkp' C0' G0' gv' cr0' *4225+ " GCA, 67, "54: 5/54; : 0]5_ " Mkv' C0' P 0' gv' cr0' *4227+ " Nature, 436, " ; : ; ; : 40]6_ " Y gludgti " O 0' M0' cpf " Mko wtc " O 0' *4232+ " Meteoritics & Planet. Sci., 45, : 95/ : 60]7_ " I qrf vglp' L0' K0' gv' cr0' *4233+ " Meteoritics & Planet. Sci., Suppl., " %72890]8_ " Ej cr r gm' J 0' O 0' gv' cr0' *4233+ " Meteoritics & Planet. Sci., Suppl., " %738: 0'