

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 " Wpkxgtuk{ " qh'P gy " O gzleq. " Crdws wgtv w. " P O : 9353. " WUC0 " , Eqpvcev' Lcpc " Dgti j qm " ³o ckl gp' pco g- < Dgtrk+ " Go ckr- [lcpce0lgti j qm B dtwngt/pcpqf g0](#) " " " "

Introduction: " O gcn' r ctvrgu " cpf " ukrcvq " ej qp/ f twrgu " kp " ED " ej qpf tkgu " ctg " uwi i guvgf " vq " j cxg " hqto gf " htqo " c " xcr qt / o gm " r nwo g " i gpgtcvqf " d { " c " o clqt " ko r cev " dgw ggp " r tqwr rmpgvt { " dqf lgu " } 3.4_0' Vj ku " uggg u " vq " dg " uwr r qtvgf " d { " vj g " { qwpi " ⁴²⁹Rd / ⁴²⁸Rd " ci gu " * ϵ 60' 85 " I c + " qh' uqo g " ej qpf twrgu " kp " vq " ED " ej qpf tkgu " * I vldc " cpf " J cJ 459+ " y j lej " r quf cvg " vj g " o quv' cpekgpv " ECKi " d { " ϵ 7 " O c " } 5_0J qy gxgt. " vj g " gzkgvpeg " qh' j ki j / r tguuwg " r j cugu " } 6_ " vj 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 " vj cv' ecwugf " uki plkecpv " tgj gcvkpi " cpf " kvgtcevkqp " dgw ggp " r tggzkvkpi " 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 { " hmwgtguegpeg " * U / ZTH+ " cpf " uecpkpi " grgevtqp " o letqueqr { " y kj " gpgti { " f kr gtukxg " Z / tc { " ur gestqo gvt { " * GF U+ " r nwu " ugtkcn' ugevkqkpi 0' Ugrgevgf " tgi kqpu " qh' kvgtguv " y gtg " cmq " gzco kpgf " y kj " grgevtqp " dcemuecwtg " f khtcevkqp " * GDUF + " cpf " GF U0' Vj g " o clp " i qcn' qh' vj ku " uwf { " ku " vq " wpf gtucpf " vj g " ej go lecn' cpf " r j { ulecn' kvgtcevkqpu " dgw ggp " r tggzkvkpi " o gcn' cpf " ko r cev " o gm " kp " I vldc " qp " vj g " Uo " / " vq " o o / uecrg0 " "

Analytical details: Hki wtg " 3 " vj qy u " vj g " I vldc " EDc " o gvgqtkg " uco r r³ vj cv' y cu " or qrkuj gf " cy c { o " f wtkpi " vj g " eqwtug " qh' vj ku " uwf { " hqt " 5F " ej go lecn' cpcn' uku0' J qy gxgt. " cm " vj g " f cvc " ctg " ucxgf " kp " j { r gtur gevten' f cvdcugu " * J { r gtO cr u+ " hqt " rvgt " tg / gzco kpevkp0' k³ Vcdrg " 3. " cpcn' vlcen' f gvcku " ctg " rkvqf " hqt " vj g " vj tgg " 5F " f cvcugw " vj cv' y gtg " r tqf wegf 0Co k c ¹ " uqhy ctg " y cu " wugf " hqt " vj g " 5F " tgeqput wevkqpu0 " "

Table 1. Analytical details.

"	μ -XRF: Vol. 1 (Fig. 2)	μ -XRF: Vol. 2 (Fig. 3)	EDS (Fig. 4)
Xqno g "	ϵ 44222 " o o 5 "	630 " o o 5 "	208 " o o 5 "
Nc {gtu "	58 "	5: "	43 "
Ugevkp " Tgr vj "	ϵ 36: " Uo "	ϵ 6: " Uo "	ϵ 6 " Uo "
Vqcnf " gr vj "	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' eqvpcvg "	ϵ 372 " ner u "	ϵ 372 " ner u "	ϵ 352 " ner u "
Ces vkiukqp " vto g " r " gt " ic " gt "	: 2 " o kp "	82 " o kp "	: 2 " o kp "
I t kpf kpi laco r r ³ r tgr " r " gt " ic " gt "	ϵ 42 " o kp "	ϵ 37 " o kp "	ϵ 37 " o kp "
Total time	ϵ 82 " j qwtu "	ϵ 72 " j qwtu "	ϵ 62 " j qwtu "

Results: " " μ -XRF. " " Vj g " I vldc " uco r r³ Hki 0' 3+ " y cu " cm quv " eqo r r³ vgn " o crr gf " y kj " U / ZTH " kp " 58 " n {gtu " cpf " c " ugevkqkpi " f gr vj " qh' ϵ 36: " Uo " * δ Xqno g " 3o + 0' C " 5F " tgeqput wevkqp " qh' vj g " Hg " * gf + " P K " * tggp+ " cpf " U " * { gmqy + " f cvc " ku " vj qy p " kp " Hki 0' 40' C v' rncuv " 7 " v { r gu " qh' o gcn' r ctvrgu " ctg " r tguqpv. " y j lej " ecp " dg " ej ctcevgtk gf " d { " vj gk " P k' eqpvqpu " * rjy < ϵ 7 " y v . " kvgtg of kvq < ϵ 80 " y v " cpf " j ki j < ϵ : 04 " y v + " cu " y gm' cu " d { " vj g " cdwvf cpeg. " uk g " cpf " vj cr gu " qh' uwrkf g " kpenwukpu " } 4_0 " " " "

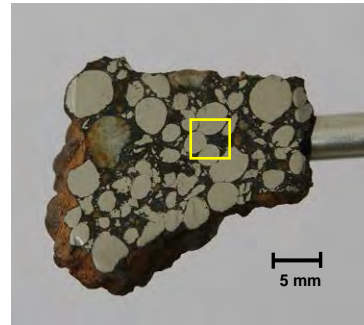


Fig. 1. Gujba sample that was used for 3D chemical analysis. The yellow box indicates the location for the 3D- μ XRF dataset "Volume 2" (shown in Fig. 3) and the 3D-EDS dataset (shown in Fig. 4).

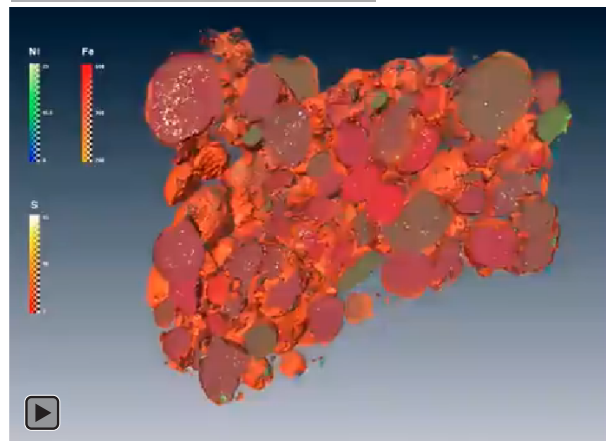


Fig. 2. 3D reconstruction (click on the image to start the movie!) of μ -XRF data (Fe: red, Ni: green, S: yellow) for the Gujba sample shown in Figure 1. Refer to the second column (μ -XRF: Vol. 1) of Table 1 for analytical details.

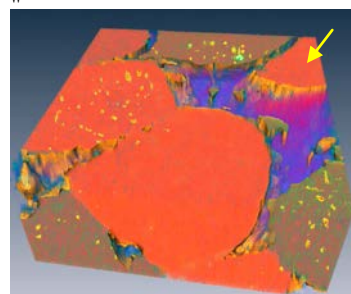


Fig. 3. 3D reconstruction of μ -XRF dataset Vol. 2 (4.82 x 4.84 x 1.78 mm) with Fe in red, Ni in green, S in yellow and Cr in blue. The location of this dataset is indicated by the yellow box in Fig. 1. Refer to the third column of Table 1 for analytical details.

Hki wtg"5"uj qy u" c"5F "tgeqputwekqp"qh"vj g"Ü/ZTH" f cvcugvöXqno g"4ö"ht "Hg"t gf + "P k"i tggp+ "U" { gmny + " cpf "Et" *dnög+0C" j ki j gt "ur cvkn'tguwnkqp"ku"pggf gf "vq" tguqrkg" 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 cv" hqt "O p" ctg'lpvgt gukpi . "y j lej "y km'dg"uj qy p"cv"vj 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"vj 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" rghv'j cpf" ukf g" eqpvckpu" uwhkf gu" hqto lpi " cp" ctewcvglkdy n'uj cr gf" vgzwtg" *dnög"cttqy u"kp" Hki 0'6+0Ctqwpf "vj g"uwhkf g/ht gg" gf i gu"qh"vj ku" i tckpu. "c" nqv"qh"uwhkf gu"ctg" hqwpf "kp" vj g" ko r cev'o gn'o cvtkz" *y j kg"cttqy u"kp" Hki 0'6+0'

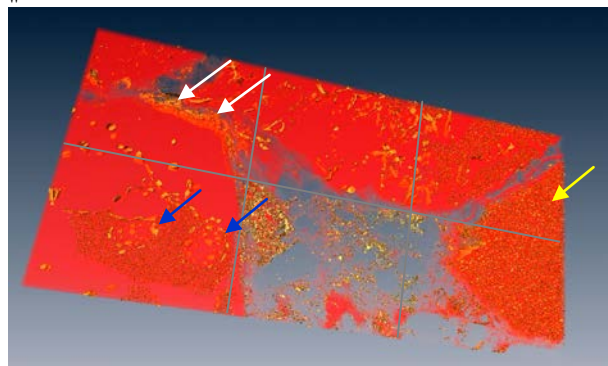


Fig. 4. 3D reconstruction of EDS data (Fe: red, S: yellow). To cover a larger area, 6 maps (3x2 – indicated by the gray lines) were put together as a mosaic for each of the 21 layers. The total size of this dataset is 3.84 mm x 1.92 mm x 80 µm. Refer to the fourth column of Table 1 for analytical details.

Combined EBSD/EDS. "Hki wtg"7"uj qy u" GF U" cpf " GDUF" f cv. "y j lej "y gtg" ces vkt gf "uko wncpgqwu" . "hqt" cp" ctgc" eqpvcklpi " c" dcttgf" qrxkpg" 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 gn'o cvtkz" kp" dgvy ggp. "eqpvcklpi" o quvn' "qh"ej ppf twrg" hci o gpw0'kp" eqpvckv" 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"vxtg{ "uj ctr "cv"cm" dw"uj qy u" c" Hk | gf" vgzwtg" *Hki 0'7c+0' Vj g" GDUF" f cv" *Hki 0'7d+ "tgxgn' vj cv" vj g" o gvcn' r ctveng" eqpvcku" qh" o cp{ "uo cm' i tckpu" *cxgtci g" f lco vgtg" ϵ32" Üo +y kj "tckn' "tcpf qo " qtkgpvckpu0'

Discussion: Qw" 5F" ej go lecn' f cv" 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" hwtj gt" o letqutwewtcn' lpxgunki cvkqp" y km' j gn" vq" wpf gtucpf " "

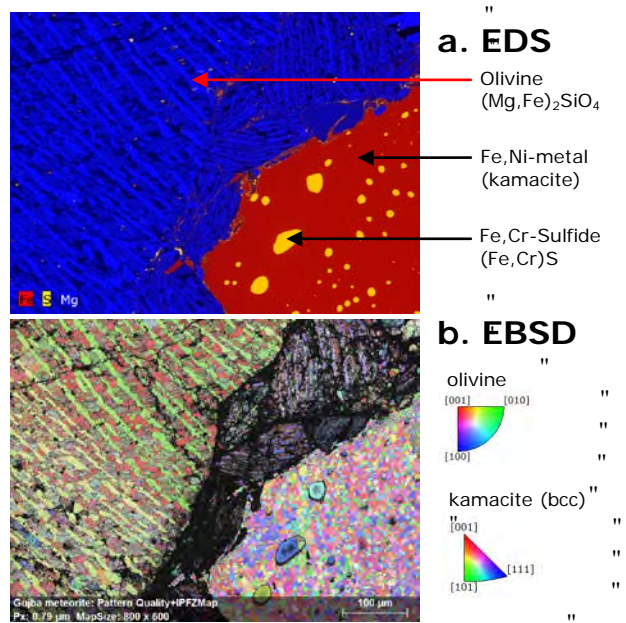


Fig. 5. a) EDS and b) EBSD (IPF-Z) data acquired simultaneously with an XFlash® 6/30 silicon-drift EDS detector and an eFlash HR EBSD detector (~70 points per second). Note the change of orientation in the olivine bars and the small grain size of the kamacite revealed by EBSD.

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 " guvdrkj " y j gtg" vj g{ " eqwv" j cxg" hqto gf" hqo " vj g" uco g" tguvtxqk" cu" uwi i guvf "d{ "3.4_0'

Hwtj gto qtg. "y kj "vj g"5F" ej go lecn' f cv" qh" I vldc. " y g" ecp" dgwgt" xkwcrk g" cpf " i teur "vj g" o ci plkwf g" qh" kvgtcevkpu" dgvy ggp" r tggzkvki "o gvcn' r ctveng" cpf "vj g" lpxcf lpi " ukrcvgt/tlej "ko r cev'o gn'o cvtkz. "uwej "cu" vj g" o qdrk' cvkqp" qh"uwhkf gu" *Hki 0'6+"cpf "o gvcn' f kuqrk' lpi " kvq" vj g" ko r cev'o gn'o cvtkz" *Hki 0'7c+0' Vj g" ugeqpf ct{ " ko r cev'gxgpv"u+r tqdcdn{ "j cf "c" uki plhtcpv" ghgev" qp" vj g" ej go lecn' cpf " kvqvr le" r tqr gtvgu" qh" EDc" o gvgtkvgu0'

Additional Information: " Oqxkgu" qh" vj g" 5F" tgeqputwekqp" ctg' r tqxkf gf "cv" [j wr \langlely y Qltwrgt \(eqo_luvtxleglqf_wecvqp/vtcklpi_ly_gdkpctulz/tc{/o_letqpcn'uku/cpf/gduf_leqo_dkplpi/o_gcuwtgo_gpvo_gv_qf_uj_vo_n'](http://www.dlyy.com/Qtwrgt/eqo_luvtxleglqf_wecvqp/vtcklpi_ly_gdkpctulz/tc{/o_letqpcn'uku/cpf/gduf_leqo_dkplpi/o_gcuwtgo_gpvo_gv_qf_uj_vo_n/)

References: [3] Eco r dgm' C0' L0' gv' cr0' *4224+ "GCA, 66, "869/8820" [4] Twdlp' C0' G0' gv' cr0' *4225+ "GCA, 67, "54: 5/54; : 0']5_ "Miqv' C0' P0' gv' cr0' *4227+ "Nature, 436, " ; ; ; ; 40']6_ "Y gludgti "O0' M0' cpf "Mko wtc" O0' *4232+ "Meteoritics & Planet. Sci., 45, : 95/ : 60']7_ "I qrf uvgkp' L0' K0' gv' cr0' *4233+ "Meteoritics & Planet. Sci., Suppl., " %72890" [8] "Ej cr r gm' J O0' O' gv' cr0' *4233+ "Meteoritics & Planet. Sci., Suppl., " %738: 0'