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# A Compilation of New and Published Major and Trace Element Data for NIST SRM 610 and NIST SRM 612 Glass Reference Materials

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Microanalytical trace element techniques (such as ion probe or laser ablation ICP-MS) are hampered by a lack of well characterized, homogeneous standards. Two silicate glass reference materials produced by National Institute of Standards and Technology (NIST), NIST SRM 610 and NIST SRM 612, have been shown to be homogeneous and are spiked with up to sixty one trace elements at nominal concentrations of 500 µg g$^{-1}$ and 50 µg g$^{-1}$ respectively. These samples (supplied as 3 mm wafers) are equivalent to NIST SRM 611 and NIST SRM 613 respectively (which are supplied as 1 mm wafers) and are becoming more widely used as potential microanalytical reference materials. NIST however, only certifies up to eight elements in these glasses. Here we have compiled concentration data from approximately sixty published works for both glasses, and have produced new analyses from our laboratories. Compilations are presented for the matrix composition of these glasses and for fifty eight trace elements. The trace element data includes all available new and published data, and summaries present the overall average and standard deviation, the range, median, geometric mean and a preferred average (which excludes all data outside ± one standard deviation of the overall average). For the elements which have been certified, there is a good agreement between the compiled averages and the NIST data. This compilation is designed to provide useful new working values for these reference materials.

*Les techniques de micro-analyses d'éléments en trace (par sonde ionique ou ICP-MS avec ablation laser) sont génées par l'absence de standards homogènes et bien caractérisés. Deux verres silicatés de référence, les verres NIST SRM 610 et NIST SRM 612, ont été démontrés homogènes et contiennent jusqu'à soixante et un élements en trace à des concentrations nominales de 500 µg g$^{-1}$ ou 50 µg g$^{-1}$ respectivement. Ces verres (qui sont fournis sous forme de galette de 3 mm d'épaisseur) sont équivalents aux standards NIST SRM 611 et NIST SRM 613 (qui eux sont fournis sous forme de galettes de 1 mm d'épaisseur) et sont de plus en plus utilisés comme étalon de référence en micro-analyse. Néanmoins, NIST ne certifie que jusqu'à huit éléments dans ces verres. Nous avons donc compilé les données publiées dans environ soixante articles sur ces deux verres et donnons aussi les résultats des analyses faites dans nos laboratoires.*
*Sont compilées les données sur les éléments composant la matrice de ces verres ainsi que sur cinquante-huit élements en trace. La compilation pour les éléments en trace, qui regroupe toutes les données disponibles déjà publiées ou faites récemment, donne en synthèse la valeur moyenne et la déviation standard associée (±), ainsi que la gamme de dispersion, la médiane, la moyenne géométrique et la valeur moyenne recommandée (calculée en excluant les données à plus d'un sigma de la moyenne générale). Pour les élements déjà certifiés par NIST, on remarque le bon accord entre leurs valeurs recommandées et nos moyennes ainsi compilées. Cette compilation fournit donc un ensemble de données à utiliser comme base de travail pour ces matériaux de référence.*



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Trace element microanalytical techniques suffer from a lack of homogeneous, well characterized trace element reference materials (see for example Hinton 1990, Perkins and Pearce 1995 and Pearce et al. 1996). The National Institute of Standards and Technology (NIST) produces a series of silicate glasses available as 3 mm wafers (including NIST SRM 610 and NIST SRM 612) which have been spiked with up to sixty one separate trace elements. NIST SRM 610 contains trace elements at a nominal 500 µg $g^{-1}$ concentration and NIST SRM 612 is at a nominal 50 µg $g^{-1}$. The same materials are available as 1 mm wafers as NIST SRM 611 (500 µg $g^{-1}$) and NIST SRM 613 (50 µg $g^{-1}$). In this compilation we include data for NIST SRM 611 with NIST SRM 610, and data for NIST SRM 613 with NIST SRM 612, making no distinction between these wafers. NIST certifies only eight elements in these glasses (Fe, Mn, Ni, Rb, Sr, Pb, Th and U in NIST SRM 610 and Fe, Ni, Rb, Sr, Ag, Pb, Th and U in NIST SRM 612) for an entire wafer, not for a fragment thereof. Information values are given for nine further elements in NIST SRM 610 and eighteen further elements in NIST SRM 612. In the certificate issued in January 1992, NIST states that "no element has been proven heterogeneous outside [5 percent] for the SRM wafer used in its entirety. However, spatial inhomogeneity does exist within each wafer", although no indication of which elements, or to what extent, is given. Hinton et al. (1995), however, have shown, in an ion microprobe study, that the NIST SRM 610 is homogeneous to ± 1% relative, and that these reference materials are suitable for use as microanalysis standards. It is not the intention of this contribution to prove the homogeneity of these glasses. Whilst studies have been undertaken in one of our laboratories in an attempt to demonstrate the homogeneity of the NIST glasses, problems arise due to element fractionation from the glasses during laser ablation inductively coupled plasma-mass spectrometry (LA-ICP-MS) and minor changes in instrumental response mean that this cannot be shown by LA-ICP-MS (see Jeffries et al. 1996, Jeffries 1996).

The NIST SRM 610 and NIST SRM 612 glass wafers are, however, becoming more widely used as reference materials in microanalytical techniques which require homogeneous trace element standards. These techniques include ion-probe analysis (see for example Hinton 1990 and Hinton et al. 1995) and more recently, LA-ICP-MS, (see for example Jackson et al. 1992, Westgate et al. 1994, Perkins and Pearce 1995 and Pearce et al. 1996). LA-ICP-MS requires the knowledge of an internal standard in the material being analysed for calibration as (analyte/internal standard) against a reference material. An ideal internal standard would be the minor isotope of a major element in the sample, which can be determined easily by electron probe micro-analysis. The calibration then only needs to be scaled for the differences in internal standard concentration between the sample and the reference material (see Perkins and Pearce 1995 for further details). An accurate knowledge of the matrix composition of the NIST glasses is thus also important.

Here we have compiled available published compositional data for the NIST SRM 610 and 612 glasses, and include new analytical data for both their major and trace element compositions, determined by a variety of analytical methods in five separate laboratories. We have excluded from our compilation publications which only present isotope ratio measurements. We are only aware of one previous compilation for these glasses (Gladney et al. 1987) which included data from approximately twenty five sources, as well as some isotope ratio determinations.

## Analytical techniques and new data: this study

### Matrix composition

In LA-ICP-MS analysis, normalisation of the response for an analyte to a minor isotope of a major element internal standard is normal practice (e.g. analyte/$^{43}$Ca, analyte/$^{29}$Si, see Perkins and Pearce 1995) with the major element determined by an external method (such as electron probe or from mineral stoichiometry). The results are then scaled for differences in the major element internal standard concentrations between the standard and the unknown. If the NIST values for the major elements are used for internal standardisation, particularly using NIST SRM 610, a significant error (around 3%) will be introduced. Accurate knowledge of the matrix composition is thus important.

The matrix composition of the major elements in NIST SRM 610 and NIST SRM 612 were determined by wavelength dispersive spectrometry methods on a Cameca SX-50 microprobe in the Department of Geology, University of Toronto. Small fragments of glass were mounted in resin blocks and polished prior to analyses. Concentrations were produced using the "PAP" procedure for quantitative analysis, which gives combined corrections for absorption and atomic number effects (Pouchou and Pichoir 1985). Calibration was achieved for various elements as follows: Si, Al, Na, K - obsidian standard, University of Alberta; Fe, Mg - pyrope; Ca, Mn - bustamite; Ti - synthetic TiAl - pyroxene glass; Cl - tugtupite. A defocussed beam was used (15 µm) accelerated to 15 kV with a 6 nA current, and elements were analysed in the following order simultaneously: Spectrometer 1 (TAP) - Na, Si, Mg, Al; Spectrometer 2 (LiF) - Fe, Mn; Spectrometer 3 (PET) - K, Ti, Cl, Ca. For both NIST SRM 610 and NIST SRM 612 a total of twenty analyses were made from four separate chips of glass. Detection limits are about 0.03% m/m oxide (3 sigma). The matrix composition, when scaled to 100%, compares extremely well with the nominal composition used for the matrix by NIST (i.e. 72% $SiO_2$, 2% $Al_2O_3$, 12% CaO and 12% $Na_2O$). Absolute values are lower than the NIST "matrix" composition due to the dilution effect of adding some sixty one elements at about 500 µg $g^{-1}$.

NIST SRM 610 was also analysed for its matrix composition by electron probe at Memorial University. The electron microprobe used was a Cameca SX50. Analyses were performed using energy dispersive detection for the major constituents (Na, Al, Si, Ca) plus K and Mg and wavelength dispersive detection for the other minor constituents (Ti, Mn, Fe, V). A ZAF correction procedure was employed. Calibration standards were as follows: Na - NaBe-phosphate; Mg - periclase; Al - corundum; Si - quartz; K - K-feldspar; Ca - wollastonite; Ti - ilmenite; Mn - $MnTiO_3$; Fe - fayalite; V - PbV-chloride. It appears that Na may have been lost from this analysis whilst the other major elements compare favourably with the Toronto data.

Data for the matrix compositions of NIST SRM 610 and NIST SRM 612 are presented in Tables 1 and 2 respectively.

## Trace elements

New trace element data for up to fifty eight elements from this study are presented in Table 3 for NIST SRM 610 and in Table 4 for NIST SRM 612. Data from five laboratories have been incorporated into these tables and include analyses by solution nebulisation ICP-MS (with a variety of dissolution methods being employed), ICP-AES, AAS, EPMA (for some elements in NIST SRM 610 ) and INAA. The analytical methods used in each laboratory are described below. EPMA conditions have been described in the previous section.

**Solution ICP-MS and AAS analyses, Aberystwyth:** Discs of both NIST SRM 610 and NIST SRM 612 were broken into small fragments. Four 0.3 g (approximately)

Table 1.
**Compilation of new and published analyses for the matrix of NIST SRM 610. Analyses in % m/m oxide. The overall average excludes the low $Na_2O$ data from Memorial EPMA. The "matrix scaled" column normalizes the $SiO_2$, $Al_2O_3$, $Na_2O$ and CaO content to 100%**

| | NIST, nominal matrix | Toronto EPMA, this study, average (n=20) | Memorial EPMA, this study, average (n=19) | (A) average | Overall average | Overall average, scaled | NIST nominal matrix | |
|---|---|---|---|---|---|---|---|---|
| $SiO_2$ | 72 | 69.895 ± 0.214 | 70.400 ± 0.400 | 69.63 ± 0.27 | 69.975 ± 0.391 | 72.276 | 72 | $SiO_2$ |
| $TiO_2$ | | 0.070 ± 0.025 | 0.076 ± 0.012 | 0.08 ± 0.01 | 0.075 ± 0.005 | | | $TiO_2$ |
| $Al_2O_3$ | 2 | 1.936 ± 0.027 | 1.960 ± 0.090 | 2.22 ± 0.01 | 2.039 ± 0.157 | 2.106 | 2 | $Al_2O_3$ |
| FeO | | 0.059 ± 0.023 | 0.039 ± 0.024 | 0.07 ± 0.02 | 0.056 ± 0.016 | | | FeO |
| MnO | | 0.053 ± 0.025 | 0.060 ± 0.031 | 0.05 ± 0.03 | 0.054 ± 0.005 | | | MnO |
| MgO | | 0.067 ± 0.012 | 0.057 ± 0.006 | 0.07 ± 0.01 | 0.065 ± 0.007 | | | MgO |
| CaO | 12 | 11.370 ± 0.083 | 11.270 ± 0.140 | 11.71 ± 0.03 | 11.450 ± 0.231 | 11.827 | 12 | CaO |
| $Na_2O$ | 14 | 13.833 ± 0.090 | 8.200 ± 0.300 | 12.87 ± 0.08 | 13.352 ± 0.681 | 13.791 | 14 | $Na_2O$ |
| $K_2O$ | | 0.061 ± 0.019 | 0.057 ± 0.026 | 0.06 ± 0.01 | 0.059 ± 0.002 | | | $K_2O$ |
| Cl | | 0.047 ± 0.016 | | | 0.047 ± 0.000 | | | Cl |
| $P_2O_5$ | | | | 0.12 ± 0.02 | 0.120 ± 0.000 | | | $P_2O_5$ |
| Total | 100 | 97.389 | 92.119 | 96.88 ± 0.13 | 97.292 | 100.000 | 100 | Total |

± one standard deviation.

(A) Hollocher and Ruiz (1995).

Table 2.
**Compilation of new and published analyses for the matrix of NIST SRM 612. Analyses in % m/m oxide. The "matrix scaled" column normalizes the $SiO_2$, $Al_2O_3$, $Na_2O$ and CaO content to 100%**

| | Toronto EPMA this study, average (n=20) | (A) | (B) average (n=10) | (C) average | (D) average | (E) activation analysis | (E) superprobe 733 | Overall average | Overall average, scaled | NIST nominal matrix |
|---|---|---|---|---|---|---|---|---|---|---|
| $SiO_2$ | 72.29±0.22 | 71.5 | 72.17±0.35 | | | 72.90±1.40 | 70.65 | 71.90±0.96 | 71.79 | 72 |
| $TiO_2$ | 0.02±0.02 | | 0.01±0.01 | | | | | 0.01±0.00 | | |
| $Al_2O_3$ | 2.01±0.04 | 2.15 | 2.32±0.01 | | | 2.10±0.04 | 1.96 | 2.11±0.16 | 2.10 | 2 |
| FeO | 0.01±0.02 | 0.027 | 0.02±0.01 | | | | | 0.02±0.00 | | |
| MnO | 0.01±0.02 | | 0.01±0.02 | | | | | 0.01±0.00 | | |
| MgO | 0.00±0.00 | | | | | | | 0.00 | | |
| CaO | 11.77±0.11 | 11.4 | 12.09±0.50 | 12.10±0.20 | 12.30±1.00 | | | 11.93±0.22 | 11.91 | 12 |
| $Na_2O$ | 14.18±0.10 | 13 | 13.16±0.07 | 14.20±0.20 | 14.40±0.80 | | | 13.98±0.56 | 13.96 | 14 |
| $K_2O$ | 0.01±0.01 | 0.02 | 0.01±0.01 | | | | | 0.01±0.00 | | |
| Cl | 0.02±0.02 | | | | | | | 0.02 | | |
| $P_2O_5$ | | | 0.01±0.01 | | | | | 0.01 | | |
| Total | 100.319 | 98.117 | 99.8 | | | | | 100.009 | 100.000 | 100 |

± one standard deviation.

(A) Jackson *et al.* (1992), (B) Hollocher and Ruiz (1995), (C) Kanda *et al.* (1980), (D) Kuleff *et al.* 1984, (E) Penev *et al.* 1985.

splits from each glass were weighed accurately into 50 ml PTFE beakers and taken into solution using a repeated open, hot $HF/HClO_4$ attack. After a final evaporation of 2 ml $HClO_4$, samples were treated with 5 ml of $HNO_3$ and made up to 100 ml solution in 10% m/m $HNO_3$. All acids used were AristaR® or Primar® Grade. Two blanks were also treated with the same volumes of acid and subtracted from the final analyses.

Fully quantitative analyses were performed using a VG Elemental ICP-MS PlasmaQuad II+ with modified (1992) high sensitivity interface. Calibration was achieved using multi-element synthetic standards made from Aldrich 1 mg $ml^{-1}$ Atomic Absorption single element solutions. With the exception of the REE, calibration samples contained ten to fifteen elements held in dilute acid at concentrations appropriate to the abundance of trace elements in natural rocks. The REE calibration sample used in this study was made to have equal concentrations of all REE, reflecting the expected concentration in the NIST glasses, and to minimise any effect from poly-atomic oxide spectral overlap during analysis.

Each of the four separate digestions for each glass was analysed five times. These were corrected for sample weight and instrument drift, and the means of the five runs for each digestion were then averaged to give the concentration (with standard deviation) of fifty elements in the original glass (see Tables 3 and 4). Relative standard deviations (RSDs) were generally small across the separate determinations, giving a good indication of the reproducibility of ICP-MS for this type of analysis (typically, RSD $<$ 3% for Z $>$ 30). For low Z elements, RSDs were greater, a result of the lower sensitivity of ICP-MS at low Z.

Cu and Zn in NIST SRM 612 and NIST SRM 610 were also determined at Aberystwyth by atomic absorption, whilst the concentrations of K in NIST SRM 612 and Li and K in NIST SRM 610 were determined by flame emission using a Perkin-Elmer 2380 spectrophotometer. Calibration was performed using mixed element standards.

The overall reproducibility of results for most elements (excluding Nb, Ta, Zr and Hf) from the four separate determinations is indicative of a homogeneous glass at the 0.3 g scale of sampling.

**Solution ICP-MS analyses, Notre Dame:** A VG Instruments PlasmaQuad II+ STE ICP-MS was used to analyse a sample of NIST SRM 610 and NIST SRM 612. The sample (20 mg) was digested in 40 drops of HF and 25 drops of concentrated $HNO_3$ (both prepared by double distillation) left on a hotplate in PTFE overnight and subsequently evaporated to dryness. After cooling, a further 15 drops of $HNO_3$ were added prior to a final evaporation to dryness.

Table 3.
New analytical data (µg g-1) from this study for NIST SRM 610

| | ICP-MS Aberystwyth | AAS Aberystwyth | EPMA Toronto | ICP-MS Notre Dame | ICP-MS Memorial | ICP-AES Memorial | ICP-MS sinter, Memorial | EPMA Memorial | INAA Toronto | |
|---|---|---|---|---|---|---|---|---|---|---|
| Ag | 212.3 ± 3.2 | | | | | | | | | Ag |
| As | | | | | | | | | 303 ± 3 | As |
| Au | 15.6 ± 4.1 | | | | | | | | 22.6 ± 0.3 | Au |
| B | | | | | | | | | | B |
| Ba | 411.2 ± 3.2 | | | 473.33 ± 4.33 | 448 ± 6 | 424 ± 14 | 382 ± 12 | | | Ba |
| Be | 481.4 ± 12.9 | | | 540.67 ± 7.9 | 452 ± 12 | 421 ± 13 | | | | Be |
| Bi | 379.1 ± 7.7 | | | 113.7 ± 2.31 | 387 ± 10 | | | | | Bi |
| Cd | 264.7 ± 1.3 | | | | | | | | | Cd |
| Ce | 430.3 ± 2.0 | | | 452.1 ± 1.77 | 462 ± 6 | 450 ± 15 | 428 ± 7 | | 463 ± 10 | Ce |
| Cl | | | 470 ± 160 | | | | | | | Cl |
| Co | 422.2 ± 9.1 | | | 436.17 ± 9.46 | | 418 ± 18 | | | 444 ± 2 | Co |
| Cr | 381.1 ± 15.6 | | | 461.77 ± 11.7 | 406 ± 18 | 343 ± 6 | | | | Cr |
| Cs | 320.3 ± 4.0 | | | 458.33 ± 5.3 | 369 ± 7 | | | | 395 ± 1 | Cs |
| Cu | 350.2 ± 12.0 | 420 ± 5.6 | | 462.7 ± 2.26 | 460 ± 12 | 431 ± 15 | | | | Cu |
| Dy | 439.0 ± 1.6 | | | 409.6 ± 6.86 | 448 ± 24 | | 429 ± 9 | | | Dy |
| Er | 439.2 ± 2.2 | | | 404.07 ± 8.67 | 463 ± 24 | | 436 ± 10 | | | Er |
| Eu | 442.7 ± 3.1 | | | 433.27 ± 3.02 | 460 ± 16 | | 439 ± 12 | | 458 ± 1 | Eu |
| Fe | 461.0 ± 34.4 | | 455 ± 177 | | | 517 ± 19 | | 299 ± 187 | | Fe |
| Ga | 436.5 ± 15.6 | | | 501.3 ± 6.98 | | 395 ± 13 | | | | Ga |
| Gd | 425.2 ± 2.5 | | | 430.53 ± 3.64 | 433 ± 28 | | 447.5 ± 11.5 | | | Gd |
| Ge | 391.3 ± 9.9 | | | | | | | | | Ge |
| Hf | 312.7 ± 20.4 | | | 405 ± 7.35 | 440 ± 19 | | 416 ± 9 | | 406 ± 3 | Hf |
| Ho | 460.3 ± 3.1 | | | 439.1 ± 8.15 | 460 ± 25 | | 439 ± 11 | | | Ho |
| In | 461.2 ± 18.5 | | | | | | | | | In |
| K | | 456.2 ± 4.98 | 503 ± 157 | | | 442 ± 6 | | 472 ± 222 | | K |
| La | 432.5 ± 1.4 | | | 443.87 ± 0.52 | 438 ± 4 | 453 ± 11 | 421 ± 6 | | 452 ± 3 | La |
| Li | 536.3 ± 12.5 | 495.7 ± 4.1 | | 457.2 ± 6.92 | 453 ± 17 | | | | | Li |
| Lu | 439.7 ± 2.5 | | | 440.57 ± 6.94 | 440 ± 19 | | 416 ± 7 | | 469 ± 0.5 | Lu |
| Mg | 488.0 ± 12.4 | | 511 ± 92 | | | 421 ± 13 | | 436 ± 48 | | Mg |
| Mn | 440.8 ± 7.4 | | 409 ± 193 | | | 392 ± 20 | | 464 ± 242 | | Mn |
| Mo | 407.5 ± 3.1 | | | 276 ± 10 | 398 ± 3 | 319 ± 11 | | | | Mo |
| Nb | 248.5 ± 81.3 | | | 432.17 ± 12.4 | 225 ± 45 | | 305 ± 219 | | | Nb |
| Nd | 426.1 ± 1.5 | | | 435.17 ± 3.06 | 435 ± 5 | | 424 ± 10 | | | Nd |
| Ni | 445.7 ± 15.4 | | | 495.47 ± 5.29 | | 341 ± 15 | | | | Ni |
| P | 304.9 ± 54.0 | | | | | 380 ± 9 | | | | P |
| Pb | 389.0 ± 7.0 | | | 301.4 ± 2.94 | 419 ± 1.2 | 381 ± 11 | | | | Pb |
| Pr | 462.9 ± 2.9 | | | 422.8 ± 2.67 | 460 ± 9 | | 441 ± 10 | | | Pr |
| Rb | 423.8 ± 6.6 | | | 501.97 ± 0.71 | 450 ± 6 | | | | 400 ± 30 | Rb |
| Re | | | | | | | | | | Re |
| Sb | 340.4 ± 18.6 | | | | | | | | | Sb |
| Sc | 445.4 ± 14.1 | | | 449.07 ± 13.8 | 444 ± 20 | 486 ± 13 | | | 442 ± 1 | Sc |
| Se | | | | | | | | | | Se |
| Sm | 449.4 ± 2.0 | | | 449.33 ± 4.81 | 458 ± 18 | | 433 ± 12 | | 475 ± 0.5 | Sm |
| Sn | 309.4 ± 43.6 | | | | | | | | | Sn |
| Sr | 491.9 ± 14.7 | | | 514.93 ± 4.93 | 512 ± 9 | 459 ± 17 | | | | Sr |
| Ta | 293.1 ± 120.0 | | | 340.13 ± 7.13 | 134 ± 23 | | 304 ± 22 | | 525 ± 1 | Ta |
| Tb | 454.8 ± 3.2 | | | 461.77 ± 5.78 | 457 ± 24 | | 414 ± 12 | | 455 ± 2 | Tb |
| Th | 527.6 ± 2.5 | | | 403.63 ± 2.22 | 454 ± 14 | 472 ± 20 | 396 ± 6 | | 458 ± 2 | Th |
| Ti | 437.3 ± 20.2 | | 421 ± 150 | 524.43 ± 4.56 | | 442 ± 9 | | 458 ± 74 | | Ti |
| Tl | 61.2 ± 2.1 | | | | 60.5 ± 0.8 | | | | | Tl |
| Tm | 422.6 ± 2.3 | | | 407.9 ± 8.11 | 454 ± 20 | | 426 ± 10 | | | Tm |
| U | 513.3 ± 0.9 | | | 432.27 ± 5.6 | 464 ± 15 | | | | | U |
| V | 448.6 ± 18.5 | | | 369 ± 7.84 | 434 ± 17 | 435 ± 17 | | 372 ± 141 | | V |
| W | | | | | | | | | | W |
| Y | 469.6 ± 8.8 | | | 531.47 ± 2.75 | 438 ± 2 | 480 ± 11 | 423.9 ± 2.3 | | | Y |
| Yb | 450.6 ± 2.1 | | | 435.83 ± 8.49 | 459 ± 22 | 434 ± 10 | | | 496 ± 2 | Yb |
| Zn | 411.3 ± 8.2 | 413 ± 3.1 | | 494.27 ± 4.88 | 477 ± 10 | 398 ± 11 | | | | Zn |
| Zr | 381.3 ± 14.6 | | | 482.37 ± 5.48 | 449 ± 4 | 435 ± 9 | 431.7 ± 1.3 | | | Zr |

± one standard deviation.

Table 4.
New analytical data (µg g-1) from this study for NIST SRM 612

| | ICP-MS Aberystwyth | AAS Aberystwyth | ICP-MS Notre Dame | ICP-MS Memorial | ICP-AES Memorial | ICP-MS sinter, Memorial | ICP-MS, Rb and Sr intl. std., BGS | INAA Toronto | |
|---|---|---|---|---|---|---|---|---|---|
| Ag | 18.91 ± 0.78 | | 22.57 ± 0.38 | | | | 21.11 ± 1.54 | | Ag |
| As | | | 48.14 ± 1.6 | | | | | 31 ± 1 | As |
| Au | 4.05 ± 0.81 | | | | | | | 5.1 ± 0.1 | Au |
| B | | | | | | | | | B |
| Ba | 33.6 ± 2.67 | | 38.05 ± 0.73 | | 38 ± 1 | 32.87 ± 0.11 | | 37.2 ± 0.5 | Ba |
| Be | 39.84 ± 1.68 | | | | 34.3 ± 0.8 | | 37.60 ± 3.96 | | Be |
| Bi | 31.45 ± 0.12 | | | | | | | | Bi |
| Cd | 27.63 ± 1.09 | | | | | | 28.92 ± 1.76 | | Cd |
| Ce | 33.89 ± 0.17 | | | | 38.1 ± 0.9 | 37.9 ± 0.5 | 37.82 ± 1.98 | | Ce |
| Co | 39.81 ± 2.27 | | | | 34.9 ± 0.6 | | 37.82 ± 4.40 | 37.3 ± 0.1 | Co |
| Cr | 37.94 ± 1.56 | | 38.64 ± 0.91 | | 30.1 ± 0.5 | | 19.24 ± 3.41 | | Cr |
| Cs | 35.08 ± 0.64 | | 40.51 ± 1.13 | | | | | 42.8 ± 0.3 | Cs |
| Cu | 30.76 ± 1.63 | 37.33 ± 1.77 | | | 37.8 ± 1.1 | | 52.01 ± 6.82 | | Cu |
| Dy | 35.02 ± 0.21 | | 34.99 ± .0.82 | | 31.1 ± 0.5 | 35.7 ± 0.5 | 36.72 ± 0.77 | | Dy |
| Er | 35.05 ± 0.25 | | 38.15 ± 0.6 | | | 37.7 ± 0.4 | 38.37 ± 1.21 | | Er |
| Eu | 32.68 ± 0.23 | | 33.14 ± 0.46 | | | 35.03 ± 0.2 | 35.95 ± 1.21 | 35.6 ± 0.1 | Eu |
| Fe | | | | | 115 ± 10 | | | | Fe |
| Ga | 36.74 ± 1.57 | | 36.88 ± 1.08 | | 33.5 ± 1.7 | | 38.04 ± 2.97 | | Ga |
| Gd | 36.03 ± 0.23 | | 36.31 ± 0.99 | | | 37.82 ± 1.12 | 38.26 ± 1.65 | | Gd |
| Ge | 32.77 ± 0.61 | | | | | | | | Ge |
| Hf | 26.43 ± 0.98 | | 36.99 ± 0.67 | | | 35.9 ± 0.6 | | 35 ± 0.1 | Hf |
| Ho | 38.9 ± 0.31 | | 38.7 ± 0.19 | | | 37.3 ± 0.5 | 38.59 ± 1.21 | | Ho |
| In | 37.21 ± 0.63 | | 18.44 ± 0.22 | | | | 43.43 ± 1.87 | | In |
| K | | 66.52 ± 2.01 | | | | | | | K |
| La | 33.45 ± 0.35 | | 34.02 ± 0.64 | | 36.9 ± 0.6 | 34.3 ± 0.7 | 34.63 ± 2.09 | 34.3 ± 0.2 | La |
| Li | 40.27 ± 1.95 | | 40.24 ± 1.21 | | | | 41.67 ± 1.76 | | Li |
| Lu | 39.5 ± 0.25 | | 36.51 ± 0.5 | | | 35.19 ± 0.1 | 36.72 ± 0.99 | 40 ± 0.1 | Lu |
| Mg | 85.09 ± 4.37 | | | | | | 75.21 ± 14.51 | | Mg |
| Mn | 37.37 ± 1.19 | | | | 36.8 ± 1.7 | | 39.03 ± 6.16 | | Mn |
| Mo | 38.61 ± 1.24 | | 39.68 ± 0.92 | 34 ± 3 | | | | | Mo |
| Nb | | | 37.18 ± 0.39 | | | | | | Nb |
| Nd | 33.52 ± 0.48 | | 34.73 ± 0.52 | | | 35.2 ± 0.3 | 36.17 ± 1.21 | | Nd |
| Ni | 42.32 ± 1.53 | | | | 29.2 ± 0.5 | | 43.43 ± 5.61 | | Ni |
| P | 71.21 ± 21.7 | | | | 39.1 ± 0.6 | | | | P |
| Pb | 36.96 ± 7.98 | | | | | | 41.67 ± 4.40 | | Pb |
| Pr | 35.9 ± 0.2 | | 37.01 ± 0.73 | | | 37.62 ± 0.19 | 37.82 ± 1.43 | | Pr |
| Rb | 31.02 ± 0.14 | | 31.29 ± 0.69 | | | | | 33 ± 5 | Rb |
| Re | | | 10.43 ± 0.67 | | | | | | Re |
| S | | | | | | | | | S |
| Sb | 32.27 ± 0.91 | | 38.91 ± 0.4 | | | | | | Sb |
| Sc | 37.88 ± 0.47 | | | 48 ± 13 | 40.8 ± 0.7 | | | | Sc |
| Sm | 35.62 ± 0.18 | | 37.01 ± 0.49 | | | 36.4 ± 0.4 | 37.49 ± 1.32 | 38.5 ± 0.1 | Sm |
| Sn | 36.21 ± 1.83 | | | | | | 38.81 ± 2.20 | | Sn |
| Sr | 73.56 ± 1.26 | | 72.96 ± 0.46 | | 73.9 ± 0.5 | | | | Sr |
| Ta | | | 40.51 ± 0.65 | | | | | 42 ± 0.5 | Ta |
| Tb | 38.46 ± 0.24 | | 34 ± 0.81 | | | 35.44 ± 0 | 37.16 ± 1.21 | 38.3 ± 0.1 | Tb |
| Th | 37.08 ± 0.33 | | 36.6 ± 0.62 | | | | 36.83 ± 1.76 | 38.1 ± 0.3 | Th |
| Ti | 51.35 ± 6.65 | | | | 45.7 ± 1.8 | | | 38.2 ± 0.2 | Ti |
| Tl | 14.69 ± 0.26 | | 15.02 ± 0.51 | | | | 15.28 ± 0.66 | | Tl |
| Tm | 39.15 ± 0.29 | | 37.29 ± 0.63 | | | 36.2 ± 0.4 | 36.72 ± 1.43 | | Tm |
| U | 35.39 ± 0.22 | | | | | | 37.38 ± 1.43 | 35 ± 0.5 | U |
| V | 41.44 ± 6.49 | | 36.16 ± 0.57 | | 36.6 ± 0.5 | | 46.29 ± 7.59 | | V |
| W | | | | 26.5 | | | | | W |
| Y | 38.96 ± 0.77 | | 31.45 ± 0.73 | | 40.4 ± 0.5 | 35.2 ± 0.5 | 41.67 ± 3.08 | | Y |
| Yb | 37.43 ± 0.38 | | 37.5 ± 0.98 | | | 37.1 ± 0.3 | 40.02 ± 0.99 | 42.4 ± 0.5 | Yb |
| Zn | 38.81 ± 3.2 | 35.48 ± 2.36 | 39.83 ± 1.05 | | 35 ± 0.8 | | 44.31 ± 4.18 | | Zn |
| Zr | 34.84 ± 1.31 | | 35.23 ± 0.03 | | 37.4 ± 0.3 | 33.81 ± 0.04 | | | Zr |

± one standard deviation.

The residue was taken up in 10 ml of 2% v/v $HNO_3$ before analysis. Internal standards of Hg, Sn and Cd were added to the solutions for calibration during analysis. Calibration was against multi-element standards (ranging in concentration from 1-100 ng $g^{-1}$ in solution to ensure bracketing of the unknown) prepared by SPEX Industries, New Jersey, USA. A procedural blank was subtracted.

**Solution ICP-MS analyses, Memorial:** Two digestion and corresponding data acquisition protocols were employed for routine ICP-MS analysis at Memorial. These were an acid digestion and $Na_2O_2$ sinter digestion procedure and are described fully by Jenner et al. (1990) and Longerich et al. (1990) respectively. Calibration standards for ICP-MS analyses were synthetic multi-element solutions prepared from high purity reagents ("Plasma Grade" reagents, SPEX Industries, Metuchen, N.J., USA). Analytical methods are also described by Jackson et al. (1992). The ICP-MS used was a Sciex (now Perkin Elmer-Sciex) ELAN model 250. The AA used was a Perkin Elmer 2380.

**Solution ICP-MS analyses, BGS:** A disc of NIST SRM 613 (equivalent to NIST SRM 612) was broken into small pieces and fragments placed in an agate micro-mill. The micro-mill was mechanically shaken until the glass had been reduced to a fine powder. Two aliquots of 0.1g of glass were weighed into PTFE test tubes to which 1 ml HF, 0.8 ml $HNO_3$ and 0.4 ml $HClO_4$ were added. This was heated overnight to dryness, and then redissolved in 10 ml of 25% $HNO_3$, before being made up to 100 ml in a plastic volumetric flask. All acids used were of AristaR® grade. Immediately prior to analysis each solution was further diluted by a factor of two. Duplicate analyses were performed on both solutions using a VG Instruments PlasmaQuad II+ ICP-MS. Calibration was achieved using SPEX multi-element standards 1 and 2 at 100 ng $g^{-1}$ in 1% $HNO_3$. No internal standard was added due to the presence of so many elements in the solutions, and results were finally normalised to the NIST certified concentrations of Rb and Sr to produce quantitative data.

**INAA, Toronto:** Instrumental neutron activation analyses (INAA) were performed on the NIST SRM 612 and 610 glasses at the Department of Geology, University of Toronto. Approximately 0.25 g of sample was weighed and sealed into plastic sachets prior to irradiation in a SLOWPOKEII reactor with a low neutron flux of only 2.5 x $10^{11}$ neutrons $cm^{-2}$ $s^{-1}$. Counting of the radioactive species generated was performed using a 20% efficient coaxial intrinsic Ge detector at 7, 10, 12, 17 and 38 days. Corrections for fission products and for spectral interferences were performed. The technique is fully described in Stix and Gorton (1992). Of elements normally reported by this method, the abnormal concentrations of many trace elements gave rise to certain problems with the analysis of these glasses. Chromium suffers from a Lu interference, U produces fission products which have serious consequences for Mo, Ba and La, and Ba suffers also from a Tb interference.

**A comment on Nb, Ta, Zr and Hf:** Nb and Ta give extremely high RSDs in data from Aberystwyth and Memorial, due to an inability to retain these elements in solution in the absence of $F^-$ ions (cf. Aldrich atomic absorption standards for these elements being supplied in dilute HF) or the addition of a complexing agent (Ingamells and Pitard 1986). In NIST SRM 610 the highest concentration of Nb recorded in Aberystwyth was 327.3 µg $g^{-1}$, and Ta 403.8 µg $g^{-1}$; in NIST SRM 612 the highest Nb concentration was 23.3 µg $g^{-1}$ and Ta 16.4 µg $g^{-1}$. These data are reported, therefore, as our minimum values for these elements in the NIST glasses, but no other significance is placed upon these values. High RSDs in the Memorial data (305 ± 209 µg $g^{-1}$ for Nb and 304 ± 22 µg $g^{-1}$ for Ta in NIST SRM 610) also indicate loss of these elements from solution. In the case of NIST SRM 612, the Memorial data (from Jackson 1992) of 38.9 µg $g^{-1}$ for Nb and 39.3 µg $g^{-1}$ for Ta are the average of the two (almost identical) maximum values from the analyses performed.

Jenner et al. (1990) and Fedorowich et al. (1993, see below), who both employ the same digestion methods, are unlikely to remove all the $F^-$ ions from their samples due to the relatively low boiling point of $HNO_3$ (Johnson and Maxwell 1981). This probably explains their ability to retain Nb and Ta in solution, but has implications for the longevity of any instrumental glassware (Thompson and Walsh 1983). Similarly, the ICP-MS data from Notre Dame in this study, which also used an $HF/HNO_3$ digestion, would retain Nb and Ta in solution. All solution methods for Ta report low concentrations when compared to solid sampling methods, due to loss from solution of Ta.

In addition, the Aberystwyth solution Hf data are low compared to other reported values. This may be the result of hydrolysis and precipitation of Hf during storage of solutions prior to analysis.

**LA-ICP-MS for Nb, Ta, Zr and Hf, Aberystwyth:** Due to problems retaining Nb and Ta in solution, a laser ablation ICP-MS technique was used to determine the concentrations of these elements in the NIST glasses. Silicate glasses with a composition similar to the NIST glasses have recently been produced by P and H Developments of Glossop, Derbyshire, U.K and are described by Hamilton and Hopkins (1995). These glasses have been prepared at 0, 75 and 150 µg $g^{-1}$ for forty four trace elements (including Zr, Nb and Ta, but unfortunately not Hf) and these glasses, with a blank, were used to erect calibrations for LA-ICP-MS analysis of the NIST glasses. The analytical methodology is described fully by Perkins and Pearce (1995), although a UV laser operating at 266 nm was used in place of an IR laser operating at 1064 nm. No certification exists for the P and H Developments glasses, and thus the laser ablation data produced for Zr, Nb and Ta in NIST SRM 612 by this method must be regarded with some caution. NIST SRM 610, with concentrations of these elements some 3 times higher than the 150 µg $g^{-1}$ standard, was not analysed by this method. The results for NIST SRM 612 give Zr 36.82 ± 1.50 µg $g^{-1}$, Nb 45.44 ± 1.58 µg $g^{-1}$ and Ta 48.39 ± 0.87 µg $g^{-1}$. These data are not included in the compilation tables.

## Summary of published data for NIST SRM 610 and NIST SRM 612

### Matrix composition

NIST give nominal compositions of both the NIST SRM 610 and NIST SRM 612 glass matrices as 72% $SiO_2$, 12% CaO, 14% $Na_2O$, and 2% $Al_2O_3$.

Jackson et al. (1992) and Hollocher and Ruiz (1995) have produced the only complete information relating to the matrix composition of either NIST glass reference material that the present authors have been able to find. Jackson et al. (1992) used a closed bomb ($HF/H_3BO_3$) digestion of a 0.1 g aliquot of a powdered glass bead prior to analysis by atomic absorption. These data are summarized in Table 1 and Table 2. Other authors (Kanda et al. 1980, Kuleff et al. 1984 and Penev et al. 1985) present several partial analyses of NIST SRM 612.

### Trace elements

A compilation of all published and new trace element data for NIST SRM 610 is presented in Table 6, which includes data from thirty nine publications. The abbreviations used to identify contributing techniques are listed in Table 5. New and published data are presented for NIST SRM 612 in Table 7, which includes analyses from forty nine publications. Both tables are arranged element by element in increasing order of reported concentration and giving an indication of method. NIST certifies only eight elements in the glasses SRM 610 and SRM 612, and these data are included in Tables 6 and 7, and presented separately in Tables 8 and 9 respectively, along with NIST information values for some other elements. Many of the elements added to these glasses have no concentration information other than the nominal concentration (50 or 500 µg $g^{-1}$). Of the published data, three main sources of information can be identified: (i) large studies of a wide range of elements by techniques with multi-element capabilities; (ii) studies of one or two elements requiring or testing novel or non-

Text continues on page 136

Table 5.
**Analytical method abbreviations used in the trace element compilation tables (Tables 6 and 7)**

| Code | Method |
|---|---|
| AAS | Atomic absorption spectroscopy |
| CPAA | Charged particle activation analysis |
| DNAA | Delayed neutron activation analysis |
| EPMA | Electron probe microanalysis |
| GDMS | Glow discharge mass spectrometry |
| GFAAS | Graphite furnace atomic absorption spectroscopy |
| HeAA | Helium activation analysis |
| HIAA | Heavy ion activation analysis |
| ICP-AES | Inductively coupled plasma atomic emission spectroscopy |
| ICP-MS | Inductively coupled plasma mass spectrometry |
| ID-SSMS | Isotope dilution spark source mass spectrometry |
| IDMS | Isotope dilution mass spectrometry |
| INAA | Instrumental neutron activation analysis |
| IPAA | Instrumental photon activation analysis |
| LA-ICP-MS | Laser ablation ICP-MS |
| LA-SSMS | Laser ablation spark source mass spectrometry |
| LP-MS | Laser probe mass spectrometry |
| MS | Mass spectrometry, unspecified |
| NAA | Neutron activation analysis |
| NMP | Nuclear microprobe |
| NTM | Nuclear track methods |
| PIXE | Proton induced X-ray emission |
| POL | Polarography |
| RAD | Radiography |
| SIMS | Secondary ion mass spectrometry |
| SXRF | Synchotron X-ray fluorescence |
| TCGS | Thermal neutron capture gamma ray spectrometry |

Table 6.
**Compilation of published and new concentration data (µg g-1) for NIST SRM 610. s = standard deviation. T.S. indicates data from this study, NIST data from the NIST certificate. Those publications marked * are not included in calculations of averages, range and median**

| Element, authors | Method | Conc. | s |
|---|---|---|---|
| **Ag** | | | |
| Sheibley 1975 | INAA | 180 | 80 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 212.3 | 3.2 |
| Rogers *et al.* 1987 | NMP | 229 | 13 |
| Bingham and Slater 1976 | LPMS | 231 | |
| McGinley and Schweikert 1976 | CPAA | 246 | 7 |
| NIST * | NIST | 254 | 10 |
| Benjamin *et al.* 1988 | NMP | 257 | 16 |
| Bonham and Quattlebaum 1988 | LA-SSMS | 261 | 108 |
| Rogers *et al.* 1987 | NMP | 267 | 26 |
| Raith *et al.* 1994 * | LA-ICP-MS | 276.2 | 4.3 |
| Milton and Hutton 1993* | GDMS | 585.3 | 31.9 |
| **As** | | | |
| INAA, Toronto (T.S.) | INAA | 303 | 3 |
| Bergholz *et al.* 1974 | MS | 305 | 20 |
| Benjamin *et al.* 1988 | NMP | 316.5 | 9.9 |
| McGinley and Schweikert 1976 | CPAA | 317 | 7 |
| Rogers *et al.* 1987 | NMP | 329 | 8 |
| Rogers *et al.* 1987 | NMP | 334 | 9 |
| Grey 1990 | AAS | 406 | 2 |
| **Au** | | | |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 15.63 | 4.11 |
| Bonham and Quattlebaum 1988 | LA-SSMS | 19 | 6.4 |
| Sheibley 1975 | INAA | 20 | 2 |
| INAA, Toronto (T.S.) | INAA | 22.6 | 0.3 |
| Benjamin *et al.* 1988 | NMP | 23 | 6.8 |
| NIST * | NIST | 25 | |
| McGinley and Schweikert 1976 | CPAA | 28 | 6 |
| Rogers *et al.* 1987 | NMP | 31 | 9 |
| **B** | | | |
| Bingham and Slater 1976 | LPMS | 141 | |
| Raith *et al.* 1994 * | LA-ICP-MS | 342.4 | 12.7 |
| Gladney *et al.* 1976 | TCGS | 348 | 20 |
| Owens *et al.* 1982 | ICP-AES | 348 | 13 |
| Rio *et al.* 1995 | NMP | 350 | 49 |
| NIST * | NIST | 351 | |
| Bonham and Quattlebaum 1988 | LA-SSMS | 356 | 49 |
| Gladney *et al.* 1976 | TCGS | 358 | 15 |
| Milton and Hutton 1993* | GDMS | 359.3 | 17.9 |
| Freidli *et al.* 1988a | HIAA | 360 | 60 |
| Gladney *et al.* 1976 | TCGS | 363 | 17 |
| Zachmann 1985 | ICP-AES | 368 | 12 |
| **Ba** | | | |
| ICP-MS sinter, Memorial (T.S.) | ICP-MS | 382 | 12 |
| McGinley and Schweikert 1976 | CPAA | 410 | 12 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 411.2 | 3.2 |
| Hollocher and Ruiz 1995 | ICP-MS | 420 | 26 |
| ICP-AES, Memorial (T.S.) | ICP-AES | 424 | 14 |
| ICP-MS, Memorial (T.S.) | ICP-MS | 448 | 6 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 473.33 | 4.33 |
| Raith *et al.* 1994 * | LA-ICP-MS | 507.9 | 22 |
| Rogers *et al.* 1987 | NMP | 957 | 93 |
| Benjamin *et al.* 1988 | NMP | 1160 | 130 |

| Element, authors | Method | Conc. | s |
|---|---|---|---|
| **Be** | | | |
| ICP-AES, Memorial (T.S.) | ICP-AES | 421 | 13 |
| Lass *et al.* 1982 | HIAA | 450 | 50 |
| Colin *et al.* 1987 | HIAA | 450 | 50 |
| Hollocher and Ruiz 1995 | ICP-MS | 451 | 13 |
| ICP-MS, Memorial (T.S.) | ICP-MS | 452 | 12 |
| Freidli *et al.* 1987 | HIAA | 480 | 60 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 481.4 | 12.9 |
| Friedli *et al.* 1988b | HIAA | 495 | 60 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 540.67 | 7.9 |
| **Bi** | | | |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 113.7 | 2.31 |
| Woolum *et al.* 1976 | RAD | 216 | |
| Carpenter and Pilione 1986 | NTM | 260 | 30 |
| Rogers *et al.* 1987 | NMP | 328 | 16 |
| Rogers *et al.* 1987 | NMP | 370 | 18 |
| Benjamin *et al.* 1988 | NMP | 375 | 15 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 379.1 | 7.7 |
| ICP-MS, Memorial (T.S.) | ICP-MS | 387 | 10 |
| Bergholz *et al.* 1974 | MS | 405 | 18 |
| Hollocher and Ruiz 1995 | ICP-MS | 430 | 55 |
| Raith *et al.* 1994 * | LA-ICP-MS | 495.8 | 8.72 |
| **Cd** | | | |
| Bergholz *et al.* 1974 | MS | 187 | 21 |
| Benjamin *et al.* 1988 | NMP | 255 | 19 |
| Rogers *et al.* 1987 | NMP | 256 | 16 |
| Rogers *et al.* 1987 | NMP | 262 | 31 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 264.7 | 1.3 |
| McGinley and Schweikert 1976 | CPAA | 393 | 8 |
| Raith *et al.* 1994 * | LA-ICP-MS | 413.7 | 30.5 |
| **Ce** | | | |
| McGinley and Schweikert 1976 | CPAA | 384 | 9 |
| ICP-MS sinter, Memorial (T.S.) | ICP-MS | 428 | 7 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 430.3 | 2.0 |
| Hollocher and Ruiz 1995 | ICP-MS | 431 | 13 |
| Lukaszew 1990 | SSMS | 439 | |
| ICP-AES, Memorial (T.S.) | ICP-AES | 450 | 15 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 452.1 | 1.77 |
| ICP-MS, Memorial (T.S.) | ICP-MS | 462 | 6 |
| INAA, Toronto (T.S.) | INAA | 463 | 10 |
| Benjamin *et al.* 1988 | NMP | 475 | 78 |
| Raith *et al.* 1994 * | LA-ICP-MS | 486.6 | 24 |
| Michael 1988 | EPMA | 526 | |
| Rogers *et al.* 1987 | NMP | 611 | 56 |
| **Cl** | | | |
| Webster 1992 | EPMA | 470 | 100 |
| EPMA, Toronto (T.S.) | EPMA | 470 | 160 |
| **Co** | | | |
| Sheibley 1975 | INAA | 135 | 14 |
| Bingham and Slater 1976 | LPMS | 253 | 25.7 |
| Bonham and Quattlebaum 1988 | LA-SSMS | 369 | 87 |

Table 6 (continued).
Compilation of published and new concentration data (µg g-1) for NIST SRM 610. s = standard deviation. T.S. indicates data from this study, NIST data from the NIST certificate. Those publications marked * are not included in calculations of averages, range and median

| Element, authors | Method | Conc. | s |
|---|---|---|---|
| **Co (cont.)** | | | |
| Milton and Hutton 1993* | GDMS | 370.6 | |
| Bergholz *et al.* 1974 | MS | 375 | 12 |
| Raith *et al.* 1994 * | LA-ICP-MS | 389.3 | 11.4 |
| NIST * | NIST | 390 | |
| Horn *et al.* 1994 | LA-ICP-MS | 391.1 | 11.1 |
| Heidel 1971 | EPMA | 391.4 | 22.9 |
| Hollocher and Ruiz 1995 | ICP-MS | 394 | 2 |
| Bendicho and de Loos Vollerbrecht 1990a | GFAAS | 399 | 11 |
| Rogers *et al.* 1987 | NMP | 407 | 12 |
| Benjamin *et al.* 1988 | NMP | 413 | 16 |
| ICP-AES, Memorial (T.S.) | ICP-AES | 418 | 18 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 422.2 | 9.1 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 436.17 | 9.46 |
| INAA, Toronto (T.S.) | INAA | 444 | 2 |
| **Cr** | | | |
| ICP-AES, Memorial (T.S.) | ICP-AES | 343 | 6 |
| Bergholz *et al.* 1974 | MS | 371 | 15 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 381.1 | 15.6 |
| Raith *et al.* 1994 * | LA-ICP-MS | 385.7 | 12.5 |
| Hollocher and Ruiz 1995 | ICP-MS | 394 | 9 |
| ICP-MS, Memorial (T.S.) | ICP-MS | 406 | 18 |
| Heidel 1971 | EPMA | 417.5 | 60.6 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 461.77 | 11.68 |
| Rogers *et al.* 1987 | NMP | 476 | 11 |
| Benjamin *et al.* 1988 | NMP | 485 | 20 |
| **Cs** | | | |
| Bergholz *et al.* 1974 | MS | 259 | 21 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 320.3 | 4 |
| Hollocher and Ruiz 1995 | ICP-MS | 364 | 15 |
| ICP-MS, Memorial (T.S.) | ICP-MS | 369 | 7 |
| INAA, Toronto (T.S.) | INAA | 395 | 1 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 458.33 | 5.3 |
| Benjamin *et al.* 1988 | NMP | 840 | 150 |
| **Cu** | | | |
| Bingham and Slater 1976 | LPMS | 343 | |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 350.2 | 12 |
| Heidel 1971 | EPMA | 385 | 95 |
| Rogers *et al.* 1987 | NMP | 413 | 25 |
| Hollocher and Ruiz 1995 | ICP-MS | 417 | 2 |
| AAS, Aberystwyth (T.S.) | AAS | 420 | 5.6 |
| Bendicho and de Loos Vollerbrecht 1990a | GFAAS | 428 | 6 |
| ICP-AES, Memorial (T.S.) | ICP-AES | 431 | 15 |
| Benjamin *et al.* 1988 | NMP | 436 | 14 |
| Raith *et al.* 1994 * | LA-ICP-MS | 441.1 | 20.8 |
| NIST * | NIST | 444 | 4 |
| Rogers *et al.* 1987 | NMP | 450 | 9 |
| ICP-MS, Memorial (T.S.) | ICP-MS | 460 | 12 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 462.7 | 2.26 |
| Bonham and Quattlebaum 1988 | LA-SSMS | 486 | 60 |
| Milton and Hutton 1993* | GDMS | 641.7 | 23.1 |

| Element, authors | Method | Conc. | s |
|---|---|---|---|
| **Dy** | | | |
| Lukaszew 1990 | SSMS | 343 | |
| Rogers *et al.* 1987 | NMP | 407 | 24 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 409.6 | 6.86 |
| ICP-MS sinter, Memorial (T.S.) | ICP-MS | 429 | 9 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 439.0 | 1.6 |
| ICP-MS, Memorial (T.S.) | ICP-MS | 448 | 24 |
| Benjamin *et al.* 1988 | NMP | 466 | 26 |
| Raith *et al.* 1994 * | LA-ICP-MS | 474.8 | 20.3 |
| **Er** | | | |
| Lukaszew 1990 | SSMS | 360 | |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 404.07 | 8.67 |
| McGinley and Schweikert 1976 | CPAA | 407 | 7 |
| Hollocher and Ruiz 1995 | ICP-MS | 407 | 16 |
| ICP-MS sinter, Memorial (T.S.) | ICP-MS | 436 | 10 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 439.2 | 2.2 |
| ICP-MS, Memorial (T.S.) | ICP-MS | 463 | 24 |
| Raith *et al.* 1994 * | LA-ICP-MS | 515.7 | 33.7 |
| Benjamin *et al.* 1988 | NMP | 519 | 29 |
| Rogers *et al.* 1987 | NMP | 526 | 35 |
| **Eu** | | | |
| Lukaszew 1990 | SSMS | 357 | |
| Hollocher and Ruiz 1995 | ICP-MS | 420 | 11 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 433.27 | 3.02 |
| ICP-MS sinter, Memorial (T.S.) | ICP-MS | 439 | 12 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 442.7 | 3.1 |
| INAA, Toronto (T.S.) | INAA | 458 | 1 |
| ICP-MS, Memorial (T.S.) | ICP-MS | 460 | 16 |
| Raith *et al.* 1994 * | LA-ICP-MS | 466.2 | 17.1 |
| Benjamin *et al.* 1988 | NMP | 575 | 57 |
| Rogers *et al.* 1987 | NMP | 731 | 46 |
| **Fe** | | | |
| Milton and Hutton 1993* | GDMS | 216.5 | 4.7 |
| Bingham and Slater 1976 | LPMS | 260 | |
| EPMA, Memorial (T.S.) | EPMA | 299 | 187 |
| Bonham and Quattlebaum 1988 | LA-SSMS | 432 | 65 |
| Bendicho and de Loos Vollerbrecht 1990a | GFAAS | 433 | 22 |
| McGinley and Schweikert 1976 | CPAA | 440 | 23 |
| Raith *et al.* 1994 * | LA-ICP-MS | 446.6 | 58.5 |
| EPMA, Toronto (T.S.) | EPMA | 455 | 155 |
| NIST * | NIST | 458 | 9 |
| Maienthal 1973 | POL | 460 | 10 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 461 | 34.4 |
| Rogers *et al.* 1987 | NMP | 486 | 10 |
| Benjamin *et al.* 1988 | NMP | 490 | 18 |
| ICP-AES, Memorial (T.S.) | ICP-AES | 517 | 19 |
| **Ga** | | | |
| ICP-AES, Memorial (T.S.) | ICP-AES | 395 | 13 |
| Raith *et al.* 1994 * | LA-ICP-MS | 419.6 | 20 |
| McGinley and Schweikert 1976 | CPAA | 423 | 17 |
| Joyce and Schweikert 1984 | PIXE | 431 | |

Table 6 (continued).
Compilation of published and new concentration data (µg $g^{-1}$) for NIST SRM 610. s = standard deviation. T.S. indicates data from this study, NIST data from the NIST certificate. Those publications marked * are not included in calculations of averages, range and median

| Element, authors | Method | Conc. | s |
|---|---|---|---|
| **Ga (cont.)** | | | |
| Hollocher and Ruiz 1995 | ICP-MS | 433 | 14 |
| Rogers *et al.* 1987 | NMP | 436 | 13 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 436.5 | 15.6 |
| Benjamin *et al.* 1988 | NMP | 439 | 14 |
| Horn *et al.* 1994 | LA-ICP-MS | 445.5 | 10.2 |
| Rogers *et al.* 1987 | NMP | 461 | 9 |
| Bergholz *et al.* 1974 | MS | 481 | 10 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 501.3 | 6.98 |
| **Gd** | | | |
| Lukaszew 1990 | SSMS | 331 | |
| McGinley and Schweikert 1976 | CPAA | 376 | 6 |
| Hollocher and Ruiz 1995 | ICP-MS | 407 | 17 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 425.2 | 2.5 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 430.53 | 3.64 |
| ICP-MS, Memorial (T.S.) | ICP-MS | 433 | 28 |
| ICP-MS sinter, Memorial (T.S.) | ICP-MS | 447.5 | 11.5 |
| Raith *et al.* 1994 * | LA-ICP-MS | 477 | 10.1 |
| Rogers *et al.* 1987 | NMP | 529 | 21 |
| Benjamin *et al.* 1988 | NMP | 556 | 26 |
| **Ge** | | | |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 391.3 | 9.9 |
| Benjamin *et al.* 1988 | NMP | 417 | 12 |
| Rogers *et al.* 1987 | NMP | 426 | 8 |
| Rogers *et al.* 1987 | NMP | 436 | 11 |
| Bergholz *et al.* 1974 | MS | 496 | 10 |
| **Hf** | | | |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 312.7 | 20.4 |
| Hollocher and Ruiz 1995 | ICP-MS | 374 | 13 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 405 | 7.35 |
| INAA, Toronto (T.S.) | INAA | 406 | 3 |
| ICP-MS sinter, Memorial (T.S.) | ICP-MS | 416 | 9 |
| McGinley and Schweikert 1976 | CPAA | 420 | 17 |
| ICP-MS, Memorial (T.S.) | ICP-MS | 440 | 19 |
| Benjamin *et al.* 1988 | NMP | 463 | 20 |
| Rogers *et al.* 1987 | NMP | 477 | 22 |
| Rogers *et al.* 1987 | NMP | 477 | 55 |
| **Ho** | | | |
| Lukaszew 1990 | SSMS | 358 | |
| Hollocher and Ruiz 1995 | ICP-MS | 413 | 13 |
| ICP-MS sinter, Memorial (T.S.) | ICP-MS | 439 | 11 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 439.1 | 8.15 |
| ICP-MS, Memorial (T.S.) | ICP-MS | 460 | 25 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 460.3 | 3.1 |
| Benjamin *et al.* 1988 | NMP | 485 | 24 |
| Raith *et al.* 1994 * | LA-ICP-MS | 492.2 | 13.8 |
| Rogers *et al.* 1987 | NMP | 511 | 21 |
| **In** | | | |
| Bergholz *et al.* 1974 | MS | 319 | 11 |
| McGinley and Schweikert 1976 | CPAA | 385 | 23 |
| Rogers *et al.* 1987 | NMP | 425 | 25 |

| Element, authors | Method | Conc. | s |
|---|---|---|---|
| **In (cont.)** | | | |
| Benjamin *et al.* 1988 | NMP | 449 | 30 |
| Hollocher and Ruiz 1995 | ICP-MS | 454 | 18 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 461.2 | 18.5 |
| Rogers *et al.* 1987 | NMP | 474 | 48 |
| Raith *et al.* 1994 * | LA-ICP-MS | 490.2 | 15.1 |
| **K** | | | |
| Milton and Hutton 1993* | GDMS | 420.6 | |
| ICP-AES, Memorial (T.S.) | ICP-AES | 442 | 6 |
| AAS, Aberystwyth (T.S.) | AAS | 456.2 | 4.98 |
| NIST * | NIST | 461 | |
| Raith *et al.* 1994 * | LA-ICP-MS | 468.9 | 26.4 |
| EPMA, Memorial (T.S.) | EPMA | 472 | 222 |
| EPMA, Toronto (T.S.) | EPMA | 503 | 157 |
| Bingham and Slater 1976 | LPMS | 557 | 53.8 |
| Benjamin *et al.* 1988 | NMP | 1600 | 1100 |
| **La** | | | |
| Lukaszew 1990 | SSMS | 386 | |
| Hollocher and Ruiz 1995 | ICP-MS | 396 | 16 |
| ICP-MS sinter, Memorial (T.S.) | ICP-MS | 421 | 6 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 432.5 | 1.4 |
| ICP-MS, Memorial (T.S.) | ICP-MS | 438 | 4 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 443.87 | 0.52 |
| INAA, Toronto (T.S.) | INAA | 452 | 3 |
| ICP-AES, Memorial (T.S.) | ICP-AES | 453 | 11 |
| Michael 1988 | EPMA | 514 | |
| Bergholz *et al.* 1974 | MS | 638 | 24 |
| Benjamin *et al.* 1988 | NMP | 742 | 80 |
| Rogers *et al.* 1987 | NMP | 794 | 60 |
| **Li** | | | |
| Lass *et al.* 1982 | HIAA | 354 | 27 |
| Freidli *et al.* 1987 | HIAA | 360 | 20 |
| Raith *et al.* 1994* | LA-ICP-MS | 370.9 | 14.3 |
| ICP-MS, Memorial (T.S.) | ICP-MS | 453 | 17 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 457.2 | 6.92 |
| Friedli *et al.* 1988b | HIAA | 480 | 80 |
| AAS, Aberystwyth (T.S.) | AAS | 495.7 | 4.1 |
| Freidli *et al.* 1988a | HIAA | 500 | 50 |
| Rio *et al.* 1995 | NMP | 500 | 18 |
| Rio *et al.* 1995 | NMP | 506 | 19 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 536.3 | 12.5 |
| **Lu** | | | |
| McGinley and Schweikert 1976 | CPAA | 332 | 60 |
| Lukaszew 1990 | SSMS | 389 | |
| Hollocher and Ruiz 1995 | ICP-MS | 390 | 10 |
| ICP-MS sinter, Memorial (T.S.) | ICP-MS | 416 | 7 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 439.7 | 2.5 |
| ICP-MS, Memorial (T.S.) | ICP-MS | 440 | 19 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 440.57 | 6.94 |
| Rogers *et al.* 1987 | NMP | 452 | 67 |
| INAA, Toronto (T.S.) | INAA | 469 | 0.5 |

Table 6 (continued).
**Compilation of published and new concentration data (µg g-1) for NIST SRM 610. s = standard deviation. T.S. indicates data from this study, NIST data from the NIST certificate. Those publications marked * are not included in calculations of averages, range and median**

| Element, authors | Method | Conc. | s |
|---|---|---|---|
| **Lu (cont.)** | | | |
| Rogers *et al.* 1987 | NMP | 476 | 17 |
| Benjamin *et al.* 1988 | NMP | 497 | 19 |
| Raith *et al.* 1994 * | LA-ICP-MS | 522.6 | 38.5 |
| **Mg** | | | |
| Raith *et al.* 1994 * | LA-ICP-MS | 276.2 | 13.2 |
| ICP-AES, Memorial (T.S.) | ICP-AES | 421 | 13 |
| EPMA, Memorial (T.S.) | EPMA | 436 | 48 |
| Bergholz *et al.* 1974 | MS | 472 | 22 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 488 | 12.4 |
| EPMA, Toronto (T.S.) | EPMA | 511 | 92 |
| **Mn** | | | |
| Bingham and Slater 1976 | LPMS | 216 | |
| Bergholz *et al.* 1974 | MS | 391 | 7 |
| ICP-AES, Memorial (T.S.) | ICP-AES | 392 | 20 |
| EPMA, Toronto (T.S.) | EPMA | 409 | 193 |
| Rogers *et al.* 1987 | NMP | 422 | 14 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 440.8 | 7.4 |
| Bonham and Quattlebaum 1988 | LA-SSMS | 446 | 60 |
| Milton and Hutton 1993* | GDMS | 449.5 | 17.6 |
| Benjamin *et al.* 1988 | NMP | 454 | 22 |
| EPMA, Memorial (T.S.) | EPMA | 464 | 242 |
| Raith *et al.* 1994 * | LA-ICP-MS | 466.2 | 16.7 |
| Bendicho and de Loos Vollerbrecht 1990a | GFAAS | 481 | 27 |
| NIST * | NIST | 485 | 10 |
| Heidel 1971 | EPMA | 495 | 36.7 |
| **Mo** | | | |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 276 | 10.01 |
| McGinley and Schweikert 1976 | CPAA | 294 | 12 |
| Bergholz *et al.* 1974 | MS | 307 | 19 |
| ICP-AES, Memorial (T.S.) | ICP-AES | 319 | 11 |
| Benjamin *et al.* 1988 | NMP | 381 | 14 |
| ICP-MS, Memorial (T.S.) | ICP-MS | 398 | 3 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 407.5 | 3.1 |
| Rogers *et al.* 1987 | NMP | 411 | 11 |
| Rogers *et al.* 1987 | NMP | 414 | 17 |
| Hollocher and Ruiz 1995 | ICP-MS | 427 | 7 |
| Raith *et al.* 1994 * | LA-ICP-MS | 430.9 | 17.9 |
| **Nb** | | | |
| ICP-MS, Memorial (T.S.) | ICP-MS | 225 | 45 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 248.5 | 81.3 |
| ICP-MS sinter, Memorial (T.S.) | ICP-MS | 305 | 219 |
| Benjamin *et al.* 1988 | NMP | 424 | 15 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 432.17 | 12.43 |
| Rogers *et al.* 1987 | NMP | 441 | 11 |
| Horn *et al.* 1994 | LA-ICP-MS | 456.3 | 12.3 |
| Rogers *et al.* 1987 | NMP | 458 | 16 |
| Raith *et al.* 1994 * | LA-ICP-MS | 474.6 | 18.7 |
| **Nd** | | | |
| Lukaszew 1990 | SSMS | 364 | |
| McGinley and Schweikert 1976 | CPAA | 384 | 7 |
| Hollocher and Ruiz 1995 | ICP-MS | 406 | 13 |
| ICP-MS sinter, Memorial (T.S.) | ICP-MS | 424 | 10 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 426.1 | 1.5 |
| ICP-MS, Memorial (T.S.) | ICP-MS | 435 | 5 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 435.17 | 3.06 |
| Raith *et al.* 1994 * | LA-ICP-MS | 493.3 | 9.63 |
| Michael 1988 | EPMA | 505 | |
| Rogers *et al.* 1987 | NMP | 579 | 32 |
| Benjamin *et al.* 1988 | NMP | 598 | 44 |
| **Ni** | | | |
| Bingham and Slater 1976 | LPMS | 316 | |
| ICP-AES, Memorial (T.S.) | ICP-AES | 341 | 15 |
| Bendicho and de Loos Vollerbrecht 1990a | GFAAS | 410 | 22 |
| Milton and Hutton 1993* | GDMS | 418.6 | 23.8 |
| Raith *et al.* 1994 * | LA-ICP-MS | 428.6 | 18.6 |
| Bergholz *et al.* 1974 | MS | 431 | 10 |
| Rogers *et al.* 1987 | NMP | 435 | 10 |
| Benjamin *et al.* 1988 | NMP | 441 | 14 |
| Bonham and Quattlebaum 1988 | LA-SSMS | 443 | 125 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 445.7 | 15.4 |
| Maienthal 1973 | POL | 450 | 7 |
| NIST * | NIST | 458.7 | 4 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 495.47 | 5.29 |
| Heidel 1971 | EPMA | 603.8 | 200 |
| **P** | | | |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 304.9 | 54 |
| ICP-AES, Memorial (T.S.) | ICP-AES | 380 | 9 |
| **Pb** | | | |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 301.4 | 2.94 |
| ICP-AES, Memorial (T.S.) | ICP-AES | 381 | 11 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 389 | 7 |
| Bergholz *et al.* 1974 | MS | 392 | 11 |
| Rogers *et al.* 1987 | NMP | 405 | 13 |
| Rogers *et al.* 1987 | NMP | 406 | 16 |
| Bonham and Quattlebaum 1988 | LA-SSMS | 409 | 102 |
| Grey 1990 | AAS | 411 | 16 |
| Benjamin *et al.* 1988 | NMP | 415 | 15 |
| Raith *et al.* 1994 * | LA-ICP-MS | 415.6 | 16.2 |
| ICP-MS, Memorial (T.S.) | ICP-MS | 419 | 1.2 |
| Belshaw *et al.* 1994 | SIMS | 422 | 2 |
| Barnes *et al.* 1973 | IDMS | 425.58 | 0.4 |
| NIST * | NIST | 426 | 1 |
| Broekman and Raaphorst 1983 | IDMS | 426 | 4 |
| Barnes *et al.* 1973 | IDMS | 426.15 | 0.41 |
| Broekman and Raaphorst 1983 | IDMS | 427 | 1 |
| Vargas *et al.* 1987 | HeAA | 429 | 41 |
| McGinley and Schweikert 1976 | CPAA | 430 | 100 |
| Bingham and Slater 1976 | LPMS | 448 | |
| Milton and Hutton 1993* | GDMS | 860.9 | 15.1 |

Table 6 (continued).
**Compilation of published and new concentration data (µg g-1) for NIST SRM 610. s = standard deviation. T.S. indicates data from this study, NIST data from the NIST certificate. Those publications marked * are not included in calculations of averages, range and median**

| Element, authors | Method | Conc. | s |
|---|---|---|---|
| **Pr** | | | |
| Bergholz *et al.* 1974 | MS | 318 | 14 |
| Lukaszew 1990 | SSMS | 392 | |
| McGinley and Schweikert 1976 | CPAA | 400 | 6 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 422.8 | 2.67 |
| ICP-MS sinter, Memorial (T.S.) | ICP-MS | 441 | 10 |
| ICP-MS, Memorial (T.S.) | ICP-MS | 460 | 9 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 462.9 | 2.9 |
| Raith *et al.* 1994 * | LA-ICP-MS | 467.3 | 22.3 |
| Rogers *et al.* 1987 | NMP | 493 | 46 |
| Benjamin *et al.* 1988 | NMP | 505 | 64 |
| **Rb** | | | |
| Milton and Hutton 1993* | GDMS | 318.2 | 35.4 |
| INAA, Toronto (T.S.) | INAA | 400 | 30 |
| Benjamin *et al.* 1988 | NMP | 413 | 13 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 423.8 | 6.6 |
| NIST * | NIST | 425.7 | 0.8 |
| Moore *et al.* 1973 | IDMS | 425.7 | 0.7 |
| Hollocher and Ruiz 1995 | ICP-MS | 429 | 11 |
| Bingham and Slater 1976 | LPMS | 430 | |
| Rogers *et al.* 1987 | NMP | 435 | 11 |
| Raith *et al.* 1994 * | LA-ICP-MS | 438.1 | 22.5 |
| Rogers *et al.* 1987 | NMP | 442 | 10 |
| ICP-MS, Memorial (T.S.) | ICP-MS | 450 | 6 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 501.97 | 0.71 |
| **Re** | | | |
| Hollocher and Ruiz 1995 | ICP-MS | 37 | 6 |
| Benjamin *et al.* 1988 | NMP | 68 | 16 |
| Bergholz *et al.* 1974 | MS | 206 | 9 |
| Horn *et al.* 1994 | LA-ICP-MS | 460.4 | 17.2 |
| **Sb** | | | |
| Benjamin *et al.* 1988 | NMP | 233 | 55 |
| Rogers *et al.* 1987 | NMP | 337 | 90 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 340.4 | 18.6 |
| Rogers *et al.* 1987 | NMP | 384 | 54 |
| Bergholz *et al.* 1974 | MS | 387 | 18 |
| McGinley and Schweikert 1976 | CPAA | 394 | 6 |
| **Sc** | | | |
| Rogers *et al.* .1987 | NMP | 315 | 97 |
| Hollocher and Ruiz 1995 | ICP-MS | 420 | 2 |
| Raith *et al.* 1994 * | LA-ICP-MS | 423.4 | 18.6 |
| Benjamin *et al.* 1988 | NMP | 442 | 180 |
| INAA, Toronto (T.S.) | INAA | 442 | 1 |
| ICP-MS, Memorial (T.S.) | ICP-MS | 444 | 20 |
| Horn *et al.* 1994 | LA-ICP-MS | 445.3 | 18.5 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 445.4 | 14.1 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 449.07 | 13.85 |
| ICP-AES, Memorial (T.S.) | ICP-AES | 486 | 13 |
| **Se** | | | |
| Benjamin *et al.* 1988 | NMP | 108 | 4.5 |
| Rogers *et al.* 1987 | NMP | 110 | 6 |
| Rogers *et al.* 1987 | NMP | 114 | 7 |

| Element, authors | Method | Conc. | s |
|---|---|---|---|
| **Sm** | | | |
| Hollocher and Ruiz 1995 | ICP-MS | 417 | 14 |
| ICP-MS sinter, Memorial (T.S.) | ICP-MS | 433 | 12 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 449.33 | 4.81 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 449.4 | 2.0 |
| ICP-MS, Memorial (T.S.) | ICP-MS | 458 | 18 |
| Lukaszew 1990 | SSMS | 472 | |
| INAA, Toronto (T.S.) | INAA | 475 | 0.5 |
| Raith *et al.* 1994 * | LA-ICP-MS | 527.2 | 23.7 |
| Rogers *et al.* 1987 | NMP | 597 | 25 |
| Benjamin *et al.* 1988 | NMP | 610 | 33 |
| **Sn** | | | |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 309.4 | 43.6 |
| McGinley and Schweikert 1976 | CPAA | 376 | 7 |
| Rogers *et al.* 1987 | NMP | 404 | 30 |
| Benjamin *et al.* 1988 | NMP | 409 | 35 |
| Rogers *et al.* 1987 | NMP | 458 | 59 |
| **Sr** | | | |
| Milton and Hutton 1993* | GDMS | 129.8 | 8.5 |
| Bingham and Slater 1976 | LPMS | 377 | |
| Bonham and Quattlebaum 1988 | LA-SSMS | 422 | 69 |
| ICP-AES, Memorial (T.S.) | ICP-AES | 459 | 17 |
| Benjamin *et al.* 1988 | NMP | 481 | 15 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 491.9 | 14.7 |
| McGinley and Schweikert 1976 | CPAA | 498 | 9 |
| Rogers *et al.* 1987 | NMP | 502 | 12 |
| Rogers *et al.* 1987 | NMP | 502 | 9 |
| ICP-MS, Memorial (T.S.) | ICP-MS | 512 | 9 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 514.93 | 4.93 |
| NIST * | NIST | 515.5 | 0.5 |
| Moore *et al.* 1973 | IDMS | 515.5 | 0.3 |
| Raith *et al.* 1994 * | LA-ICP-MS | 518 | 17.3 |
| **Ta** | | | |
| ICP-MS, Memorial (T.S.) | ICP-MS | 134 | 23 |
| Bergholz *et al.* 1974 | MS | 220 | 14 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 293.1 | 120 |
| ICP-MS sinter, Memorial (T.S.) | ICP-MS | 304 | 22 |
| McGinley and Schweikert 1976 | CPAA | 332 | 9 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 340.13 | 7.13 |
| Rogers *et al.* 1987 | NMP | 435 | 24 |
| Horn *et al.* 1994 | LA-ICP-MS | 440.7 | 15.8 |
| Benjamin *et al.* 1988 | NMP | 491 | 22 |
| Rogers *et al.* 1987 | NMP | 510 | 52 |
| Raith *et al.* 1994 * | LA-ICP-MS | 520.9 | 27 |
| INAA, Toronto (T.S.) | INAA | 525 | 1 |
| **Tb** | | | |
| McGinley and Schweikert 1976 | CPAA | 328 | 12 |
| Lukaszew 1990 | SSMS | 344 | |
| Hollocher and Ruiz 1995 | ICP-MS | 414 | 11 |
| ICP-MS sinter, Memorial (T.S.) | ICP-MS | 414 | 12 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 454.8 | 3.2 |

Table 6 (continued).
Compilation of published and new concentration data (µg g-1) for NIST SRM 610. s = standard deviation. T.S. indicates data from this study, NIST data from the NIST certificate. Those publications marked * are not included in calculations of averages, range and median

| Element, authors | Method | Conc. | s |
|---|---|---|---|
| **Tb (cont.)** | | | |
| INAA, Toronto (T.S.) | INAA | 455 | 2 |
| ICP-MS, Memorial (T.S.) | ICP-MS | 457 | 24 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 461.77 | 5.78 |
| Raith *et al.* 1994 * | LA-ICP-MS | 506.1 | 29.3 |
| Benjamin *et al.* 1988 | NMP | 521 | 29 |
| Rogers *et al.* 1987 | NMP | 585 | 24 |
| **Th** | | | |
| Bingham and Slater 1976 | LPMS | 249 | |
| ICP-MS sinter, Memorial (T.S.) | ICP-MS | 396 | 6 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 403.63 | 2.22 |
| Raith *et al.* 1994 * | LA-ICP-MS | 431.8 | 36.2 |
| Benjamin *et al.* 1988 | NMP | 446 | 18 |
| ICP-MS, Memorial (T.S.) | ICP-MS | 454 | 14 |
| Bonham and Quattlebaum 1988 | LA-SSMS | 455 | 110 |
| Barnes *et al.* 1973 | IDMS | 455.4 | 1.6 |
| NIST * | NIST | 457.2 | 1.2 |
| Barnes *et al.* 1973 | IDMS | 457.23 | 0.52 |
| INAA, Toronto (T.S.) | INAA | 458 | 2 |
| Bergholz *et al.* 1974 | MS | 469 | 7 |
| ICP-AES, Memorial (T.S.) | ICP-AES | 472 | 20 |
| Rogers *et al.* 1987 | NMP | 490 | 23 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 527.6 | 2.5 |
| Rogers *et al.* 1987 | NMP | 539 | 18 |
| **Ti** | | | |
| Milton and Hutton 1993* | GDMS | 41.7 | 1.7 |
| Bingham and Slater 1976 | LPMS | 257 | |
| Bergholz *et al.* 1974 | MS | 361 | 18 |
| Bonham and Quattlebaum 1988 | LA-SSMS | 408 | 71 |
| EPMA, Toronto (T.S.) | EPMA | 421 | 150 |
| Benjamin *et al.* 1988 | NMP | 423 | 46 |
| Maienthal 1973 | POL | 434 | 10 |
| NIST * | NIST | 437 | |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 437.3 | 20.2 |
| Rogers *et al.* 1987 | NMP | 441 | 30 |
| Hollocher and Ruiz 1995 | ICP-MS | 442 | 4 |
| ICP-AES, Memorial (T.S.) | ICP-AES | 442 | 9 |
| EPMA, Memorial (T.S.) | EPMA | 458 | 74 |
| Heidel 1971 | EPMA | 517.5 | 48.4 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 524.43 | 4.56 |
| **Tl** | | | |
| Milton and Hutton 1993* | GDMS | 33.6 | 2.1 |
| Bergholz *et al.* 1974 | MS | 52 | 35 |
| Raith *et al.* 1994 * | LA-ICP-MS | 58.84 | 3.81 |
| Bonham and Quattlebaum 1988 | LA-SSMS | 59 | 21 |
| McGinley and Schweikert 1976 | CPAA | 60 | 10 |
| ICP-MS, Memorial (T.S.) | ICP-MS | 60.5 | 0.8 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 61.19 | 2.06 |
| NIST * | NIST | 61.8 | 2.5 |
| Barnes *et al.* 1973 | IDMS | 61.8 | 1 |
| Rogers *et al.* 1987 | NMP | 65 | 9 |
| **Tl (cont.)** | | | |
| Benjamin *et al.* 1988 | NMP | 67.2 | 6.3 |
| Rogers *et al.* 1987 | NMP | 70 | 8 |
| **Tm** | | | |
| Lukaszew 1990 | SSMS | 366 | |
| Hollocher and Ruiz 1995 | ICP-MS | 400 | 9 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 407.9 | 8.11 |
| McGinley and Schweikert 1976 | CPAA | 410 | 9 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 422.6 | 2.3 |
| ICP-MS sinter, Memorial (T.S.) | ICP-MS | 426 | 10 |
| ICP-MS, Memorial (T.S.) | ICP-MS | 454 | 20 |
| Benjamin *et al.* 1988 | NMP | 479 | 21 |
| Raith *et al.* 1994 * | LA-ICP-MS | 490.5 | 22.1 |
| Rogers *et al.* 1987 | NMP | 517 | 19 |
| **U** | | | |
| Bergholz *et al.* 1974 | MS | 413 | 18 |
| Benjamin *et al.* 1988 | NMP | 413 | 15 |
| Rogers *et al.* 1987 | NMP | 423 | 18 |
| Bingham and Slater 1976 | LPMS | 425 | |
| Gladney *et al.* 1984 | TCGS | 431 | 40 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 432.27 | 5.6 |
| Raith *et al.* 1994 * | LA-ICP-MS | 440.1 | 23.3 |
| Rogers *et al.* 1987 | NMP | 451 | 17 |
| Carpenter 1972 | NTM | 461.3 | 1.7 |
| Barnes *et al.* 1973 | IDMS | 461.3 | 1 |
| NIST * | NIST | 461.5 | 1.1 |
| Carpenter 1972 | NTM | 461.5 | 1.1 |
| Barnes *et al.* 1973 | IDMS | 461.5 | 0.4 |
| Carpenter 1972 | NTM | 462.8 | 13.8 |
| ICP-MS, Memorial (T.S.) | ICP-MS | 464 | 15 |
| Conrad *et al.* 1982 | DNAA | 470 | 90 |
| Conrad *et al.* 1982 | DNAA | 471 | 28 |
| Bonham and Quattlebaum 1988 | LA-SSMS | 490 | 132 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 513.3 | 0.9 |
| **V** | | | |
| Bergholz *et al.* 1974 | MS | 206 | 10 |
| Raith *et al.* 1994 * | LA-ICP-MS | 342.5 | 19 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 369 | 7.84 |
| EPMA, Memorial (T.S.) | EPMA | 372 | 141 |
| Hollocher and Ruiz 1995 | ICP-MS | 426 | 1 |
| ICP-MS, Memorial (T.S.) | ICP-MS | 434 | 17 |
| ICP-AES, Memorial (T.S.) | ICP-AES | 435 | 17 |
| Horn *et al.* 1994 | LA-ICP-MS | 435.1 | 8.1 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 448.6 | 18.5 |
| Rogers *et al.* 1987 | NMP | 477 | 18 |
| Benjamin *et al.* 1988 | NMP | 482 | 30 |
| Heidel 1971 | EPMA | 486.3 | 53.1 |
| Joyce and Schweikert 1984 | PIXE | 494.2 | 54.1 |
| **W** | | | |
| McGinley and Schweikert 1976 | CPAA | 366 | 30 |
| Rogers *et al.* 1987 | NMP | 418 | 40 |

**Table 6 (continued).**
**Compilation of published and new concentration data (µg g-1) for NIST SRM 610. s = standard deviation. T.S. indicates data from this study, NIST data from the NIST certificate. Those publications marked * are not included in calculations of averages, range and median**

| Element, authors | Method | Conc. | s |
|---|---|---|---|
| **W (cont.)** | | | |
| Rogers *et al.* 1987 | NMP | 451 | 19 |
| Benjamin *et al.* 1988 | NMP | 467 | 18 |
| Raith *et al.* 1994 * | LA-ICP-MS | 528.1 | 16.7 |
| **Y** | | | |
| McGinley and Schweikert 1976 | CPAA | 271 | 7 |
| ICP-MS sinter, Memorial (T.S.) | ICP-MS | 423.9 | 2.3 |
| Benjamin *et al.* 1988 | NMP | 431 | 14 |
| ICP-MS, Memorial (T.S.) | ICP-MS | 438 | 2 |
| Hollocher and Ruiz 1995 | ICP-MS | 446 | 5 |
| Rogers *et al.* 1987 | NMP | 450 | 10 |
| Rogers *et al.* 1987 | NMP | 461 | 14 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 469.6 | 8.8 |
| ICP-AES, Memorial (T.S.) | ICP-AES | 480 | 11 |
| Raith *et al.* 1994 * | LA-ICP-MS | 502.6 | 24.7 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 531.47 | 2.748 |
| **Yb** | | | |
| Hollocher and Ruiz 1995 | ICP-MS | 400 | 10 |
| ICP-AES, Memorial (T.S.) | ICP-AES | 434 | 10 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 435.83 | 8.49 |
| Lukaszew 1990 | SSMS | 443 | |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 450.6 | 2.1 |
| ICP-MS, Memorial (T.S.) | ICP-MS | 459 | 22 |
| Raith *et al.* 1994 * | LA-ICP-MS | 467.9 | 11.9 |
| INAA, Toronto (T.S.) | INAA | 496 | 2 |
| Benjamin *et al.* 1988 | NMP | 512 | 27 |
| Rogers *et al.* 1987 | NMP | 574 | 29 |

| Element, authors | Method | Conc. | s |
|---|---|---|---|
| **Zn** | | | |
| ICP-AES, Memorial (T.S.) | ICP-AES | 398 | 11 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 411.3 | 8.2 |
| AAS, Aberystwyth (T.S.) | AAS | 413 | 3.1 |
| Hollocher and Ruiz 1995 | ICP-MS | 428 | 3 |
| Raith *et al.* 1994 * | LA-ICP-MS | 428.7 | 8.4 |
| NIST * | NIST | 433 | |
| Horn *et al.* 1994 | LA-ICP-MS | 434.4 | 38.1 |
| Benjamin *et al.* 1988 | NMP | 446 | 14 |
| Bonham and Quattlebaum 1988 | LA-SSMS | 456 | 21 |
| Bingham and Slater 1976 | LPMS | 457 | |
| Rogers *et al.* 1987 | NMP | 476 | 9 |
| Rogers *et al.* 1987 | NMP | 476 | 15 |
| ICP-MS, Memorial (T.S.) | ICP-MS | 477 | 10 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 494.27 | 4.88 |
| Milton and Hutton 1993* | GDMS | 3171 | 166.9 |
| **Zr** | | | |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 381.3 | 14.6 |
| Raith *et al.* 1994 * | LA-ICP-MS | 392.4 | 10.7 |
| Benjamin *et al.* 1988 | NMP | 408 | 14 |
| ICP-MS sinter, Memorial (T.S.) | ICP-MS | 431.7 | 1.3 |
| Rogers *et al.* 1987 | NMP | 433 | 15 |
| ICP-AES, Memorial (T.S.) | ICP-AES | 435 | 9 |
| Rogers *et al.* 1987 | NMP | 436 | 11 |
| Hollocher and Ruiz 1995 | ICP-MS | 444 | 11 |
| ICP-MS, Memorial (T.S.) | ICP-MS | 449 | 4 |
| Horn *et al.* 1994 | LA-ICP-MS | 450.5 | 15.9 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 482.37 | 5.48 |

**Table 7.**
**Compilation of published and new concentration data (µg g-1) for NIST SRM 612. s = standard deviation. T.S. indicates data from this study, NIST data from the NIST certificate. Those publications marked * are not included in calculations of averages, range and median**

| Element, authors | Method | Conc. | s |
|---|---|---|---|
| **Ag** | | | |
| Bonham and Quattlebaum 1988 | LA-SSMS | 1 | |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 18.91 | 0.78 |
| Headridge and Riddington 1984 | GFAAS | 19.5 | 0.87 |
| ICP-MS, BGS (T.S.) | ICP-MS | 21.11 | 1.54 |
| Fedorowich *et al.* 1993 | ICP-MS | 21.4 | 0.5 |
| NIST * | NIST | 22 | 0.3 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 22.57 | 0.38 |
| McGinley and Schweikert 1976a | CPAA | 28 | 5 |
| Sheibley 1973 | INAA | 31 | 7 |
| **As** | | | |
| Grey 1990 | AAS | 25.2 | 1.7 |
| INAA, Toronto (T.S.) | INAA | 31 | 1 |
| Fedorowich *et al.* 1993 | ICP-MS | 33.9 | 0.6 |
| Kanda *et al.* 1980 | IPAA | 35.6 | 0.3 |
| McGinley and Schweikert 1976a | CPAA | 38 | 9 |

| Element, authors | Method | Conc. | s |
|---|---|---|---|
| **As (cont.)** | | | |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 48.14 | 1.6 |
| Kuleff *et al.* 1984 | INAA | 58.1 | 7.3 |
| **Au** | | | |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 4.05 | 0.81 |
| NIST * | NIST | 5 | |
| Sheibley 1973 | INAA | 5 | 1 |
| Kuleff *et al.* 1984 | INAA | 5 | 0.2 |
| INAA, Toronto (T.S.) | INAA | 5.1 | 0.1 |
| Kim and Born 1973 | INAA | 5.27 | 0.11 |
| McGinley and Schweikert 1976a | CPAA | 6 | 3 |
| **B** | | | |
| Denoyer *et al.* 1991 | LA-ICP-MS | 25.8 | 1.9 |
| Rio *et al.* 1995 | AAS | 26 | 5 |
| Zachmann 1985 | ICP-AES | 27.8 | 2.9 |

Table 7 (continued).
Compilation of published and new concentration data (µg g-1) for NIST SRM 612. s = standard deviation. T.S. indicates data from this study, NIST data from the NIST certificate. Those publications marked * are not included in calculations of averages, range and median

| Element, authors | Method | Conc. | s |
|---|---|---|---|
| **B (cont.)** | | | |
| Gladney *et al.* 1984 | DNAA | 31 | 3 |
| NIST * | NIST | 32 | |
| Carpenter 1972 | NTM | 32.39 | 1.04 |
| Rio *et al.* 1995 | NMP | 33 | 6 |
| Bonham and Quattlebaum 1988 | LA-SSMS | 35 | |
| McGinley and Schweikert 1975 | CPAA | 38 | 5 |
| Rio *et al.* 1995 | NMP | 39 | 6 |
| Owens *et al.* 1982 | ICP-AES | 40 | 4 |
| Milton and Hutton 1993* | GDMS | 40 | |
| Freidli *et al.* 1988a | HIAA | 43 | 20 |
| **Ba** | | | |
| ICP-MS sinter, Memorial (T.S.) | ICP-MS | 32.87 | 0.11 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 33.6 | 2.67 |
| Hollocher and Ruiz 1995 | ICP-MS | 36 | 4 |
| Kuleff *et al.* 1984 | INAA | 36.5 | 5.2 |
| INAA, Toronto (T.S.) | INAA | 37.2 | 0.5 |
| ICP-AES, Memorial (T.S.) | ICP-AES | 38 | 1 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 38.05 | 0.73 |
| Jackson *et al.* 1992 | ICP-MS | 38.9 | 0.7 |
| Fedorowich *et al.* 1993 | ICP-MS | 39.5 | 1.6 |
| NIST * | NIST | 41 | |
| Haney 1977 | IDSSMS | 41.5 | |
| Bonham and Quattlebaum 1988 | LA-SSMS | 45 | |
| Imbert and Telouk 1993 * | LA-ICP-MS | 50.6 | 8 |
| **Be** | | | |
| Lass *et al.* 1982 | HIAA | 31 | 7 |
| ICP-AES, Memorial (T.S.) | ICP-AES | 34.3 | 0.8 |
| Hollocher and Ruiz 1995 | ICP-MS | 35.3 | 0.3 |
| Fedorowich *et al.* 1993 | ICP-MS | 37.1 | 0.4 |
| ICP-MS, BGS (T.S.) | ICP-MS | 37.6 | 3.96 |
| Jackson *et al.* 1992 | ICP-MS | 39 | 5.6 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 39.84 | 1.68 |
| Colin *et al.* 1987 | HIAA | 41 | 5 |
| Freidli *et al.* 1988b | HIAA | 48 | 7 |
| Freidli *et al.* 1987 | HIAA | 50 | 4 |
| **Bi** | | | |
| Woolum *et al.* 1976 | RAD | 13 | |
| Carpenter and Pilione 1986 | NTM | 21 | 4 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 31.45 | 0.12 |
| Jackson *et al.* 1992 | ICP-MS | 33 | 1.4 |
| Fedorowich *et al.* 1993 | ICP-MS | 33.9 | 0.4 |
| Hollocher and Ruiz 1995 | ICP-MS | 40 | 2 |
| Raith *et al.* 1994* | LA-ICP-MS | 62.33 | 1.42 |
| **Cd** | | | |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 27.63 | 1.09 |
| Fedorowich *et al.* 1993 | ICP-MS | 28.4 | 1.1 |
| ICP-MS, BGS (T.S.) | ICP-MS | 28.92 | 1.76 |
| McGinley and Schweikert 1976a | CPAA | 40 | 5 |
| **Ce** | | | |
| Imbert and Telouk 1993 * | LA-ICP-MS | 32 | 6 |

| Element, authors | Method | Conc. | s |
|---|---|---|---|
| **Ce (cont.)** | | | |
| Bonham and Quattlebaum 1988 | LA-SSMS | 33 | |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 33.89 | 0.17 |
| Pearce *et al.* 1996 | ICP-MS | 33.9 | |
| Denoyer *et al.* 1991 | LA-ICP-MS | 35.4 | 1.7 |
| Sheibley 1973 | INAA | 37 | 2 |
| Hollocher and Ruiz 1995 | ICP-MS | 37 | 3 |
| ICP-MS, BGS (T.S.) | ICP-MS | 37.82 | 1.98 |
| Jackson *et al.* 1992 | ICP-MS | 37.9 | 2 |
| ICP-MS sinter, Memorial (T.S.) | ICP-MS | 37.9 | 0.5 |
| ICP-AES, Memorial (T.S.) | ICP-AES | 38.1 | 0.9 |
| Fedorowich *et al.* 1993 | ICP-MS | 38.3 | 0.8 |
| NIST * | NIST | 39 | |
| Chen *et al.* 1993 | SXRF | 39 | |
| Raith *et al.* 1994* | LA-ICP-MS | 39.54 | 0.55 |
| Sutton *et al.* 1993 | SXRF | 40 | |
| Kanda *et al.* 1980 | IPAA | 40.6 | 0.2 |
| Haney 1977 | IDSSMS | 41.2 | |
| McGinley and Schweikert 1976a | CPAA | 43 | 2 |
| Kuleff *et al.* 1984 | INAA | 45.3 | 1.5 |
| Chenery and Cook 1993 | LA-ICP-MS | 48.2 | |
| **Co** | | | |
| Bendicho and de Loos Vollerbregt 1990b | GFAAS | 2 | 0.4 |
| Sheibley 1973 | INAA | 31 | 1 |
| Hollocher and Ruiz 1995 | ICP-MS | 32.8 | 0.4 |
| Fedorowich *et al.* 1993 | ICP-MS | 32.9 | 0.9 |
| Kanda *et al.* 1980 | IPAA | 33.3 | 1 |
| Denoyer *et al.* 1991 | LA-ICP-MS | 33.8 | 1.1 |
| Raith *et al.* 1994* | LA-ICP-MS | 34.26 | 0.36 |
| Kuleff *et al.* 1984 | INAA | 34.3 | 2.9 |
| ICP-AES, Memorial (T.S.) | ICP-AES | 34.9 | 0.6 |
| Kobayashi 1986 | NAA | 35 | 1.9 |
| NIST * | NIST | 35.5 | 1.2 |
| Bendicho and de Loos Vollerbregt 1990a | GFAAS | 36.1 | 0.9 |
| Kim and Born 1973 | INAA | 37.1 | 2.3 |
| INAA, Toronto (T.S.) | INAA | 37.3 | 0.1 |
| Kim and Born 1973 | INAA | 37.47 | 4.1 |
| ICP-MS, BGS (T.S.) | ICP-MS | 37.82 | 4.4 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 39.81 | 2.27 |
| Milton and Hutton 1993* | GDMS | 43 | |
| Imbert and Telouk 1993 * | LA-ICP-MS | 44.8 | 9.3 |
| Bonham and Quattlebaum 1988 | LA-SSMS | 84 | |
| **Cr** | | | |
| ICP-MS, BGS (T.S.) | ICP-MS | 19.24 | 3.41 |
| ICP-AES, Memorial (T.S.) | ICP-AES | 30.1 | 0.5 |
| Hollocher and Ruiz 1995 | ICP-MS | 31.2 | 0.2 |
| Fedorowich *et al.* 1993 | ICP-MS | 34.9 | 1.7 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 37.94 | 1.56 |
| Kobayashi 1986 | NAA | 38 | 4 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 38.64 | 0.91 |

Table 7 (continued).
Compilation of published and new concentration data (µg g-1) for NIST SRM 612. s = standard deviation. T.S. indicates data from this study, NIST data from the NIST certificate. Those publications marked * are not included in calculations of averages, range and median

| Element, authors | Method | Conc. | s |
|---|---|---|---|
| **Cr (cont.)** | | | |
| Raith *et al.* 1994* | LA-ICP-MS | 47.63 | 0.69 |
| Bonham and Quattlebaum 1988 | LA-SSMS | 63 | |
| Kuleff *et al.* 1984 | INAA | 65.9 | 3.7 |
| Kim and Born 1973 | INAA | 155 | 8 |
| **Cs** | | | |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 35.08 | 0.64 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 40.51 | 1.13 |
| Kim and Born 1973 | INAA | 41.1 | 6.6 |
| Jackson *et al.* 1992 | ICP-MS | 41.8 | 1.2 |
| Hollocher and Ruiz 1995 | ICP-MS | 42 | 4 |
| Fedorowich *et al.* 1993 | ICP-MS | 42.3 | 1.4 |
| INAA, Toronto (T.S.) | INAA | 42.8 | 0.3 |
| McGinley and Schweikert 1976a | CPAA | 43 | 4 |
| Kuleff *et al.* 1984 | INAA | 43 | 2 |
| Kanda *et al.* 1980 | IPAA | 44.8 | 1.2 |
| Bonham and Quattlebaum 1988 | LA-SSMS | 95 | |
| **Cu** | | | |
| Bonham and Quattlebaum 1988 | LA-SSMS | 6 | |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 30.76 | 1.63 |
| Milton and Hutton 1993* | GDMS | 32 | |
| Hollocher and Ruiz 1995 | ICP-MS | 33.5 | 0.4 |
| Raith *et al.* 1994* | LA-ICP-MS | 35.2 | 1.02 |
| Kuleff *et al.* 1984 | INAA | 37 | 4 |
| AAS, Aberystwyth (T.S.) | AAS | 37.33 | 1.77 |
| NIST * | NIST | 37.7 | 0.9 |
| ICP-AES, Memorial (T.S.) | ICP-AES | 37.8 | 1.1 |
| Bendicho and de Loos Vollerbregt 1990b | GFAAS | 38.1 | 0.8 |
| Fedorowich *et al.* 1993 | ICP-MS | 39.5 | 1.7 |
| Bendicho and de Loos Vollerbregt 1990a | GFAAS | 39.7 | 1 |
| Imbert and Telouk 1993 * | LA-ICP-MS | 44.8 | 9.4 |
| ICP-MS, BGS (T.S.) | ICP-MS | 52.01 | 6.82 |
| **Dy** | | | |
| ICP-AES, Memorial (T.S.) | ICP-AES | 31.1 | 0.5 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 34.99 | 0.82 |
| NIST * | NIST | 35 | |
| Jackson *et al.* 1992 | ICP-MS | 35 | 1 |
| Chen *et al.* 1993 | SXRF | 35 | |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 35.02 | 0.21 |
| Raith *et al.* 1994* | LA-ICP-MS | 35.23 | 0.18 |
| ICP-MS sinter, Memorial (T.S.) | ICP-MS | 35.7 | 0.5 |
| Bonham and Quattlebaum 1988 | LA-SSMS | 36 | |
| Hollocher and Ruiz 1995 | ICP-MS | 36 | 3 |
| Fedorowich *et al.* 1993 | ICP-MS | 36.4 | 0.8 |
| ICP-MS, BGS (T.S.) | ICP-MS | 36.72 | 0.77 |
| Pearce *et al.* 1996 | ICP-MS | 36.8 | |
| Kuleff *et al.* 1984 | INAA | 37 | 4 |
| Sutton *et al.* 1993 | SXRF | 37 | |
| Chenery and Cook 1993 | LA-ICP-MS | 41.7 | |
| **Er** | | | |
| Sutton *et al.* 1993 | SXRF | 32 | |
| **Er (cont.)** | | | |
| Bonham and Quattlebaum 1988 | LA-SSMS | 35 | |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 35.05 | 0.25 |
| Hollocher and Ruiz 1995 | ICP-MS | 36 | 3 |
| ICP-MS sinter, Memorial (T.S.) | ICP-MS | 37.7 | 0.4 |
| Jackson *et al.* 1992 | ICP-MS | 37.9 | 1.2 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 38.15 | 0.6 |
| ICP-MS, BGS (T.S.) | ICP-MS | 38.37 | 1.21 |
| Fedorowich *et al.* 1993 | ICP-MS | 38.4 | 0.9 |
| Pearce *et al.* 1996 | ICP-MS | 38.7 | |
| Raith *et al.* 1994* | LA-ICP-MS | 38.8 | 0.23 |
| NIST * | NIST | 39 | |
| Chen *et al.* 1993 | SXRF | 39 | |
| McGinley and Schweikert 1976a | CPAA | 43 | 1 |
| Chenery and Cook 1993 | LA-ICP-MS | 44.6 | |
| **Eu** | | | |
| Sheibley 1973 | INAA | 26 | 1 |
| Sutton *et al.* 1993 | SXRF | 31 | |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 32.68 | 0.23 |
| Kim and Born 1973 | INAA | 32.86 | 2.19 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 33.14 | 0.46 |
| Denoyer *et al.* 1991 | LA-ICP-MS | 33.4 | 1.4 |
| Hollocher and Ruiz 1995 | ICP-MS | 34 | 3 |
| Jackson *et al.* 1992 | ICP-MS | 34.4 | 1 |
| Pearce *et al.* 1996 | ICP-MS | 34.9 | |
| ICP-MS sinter, Memorial (T.S.) | ICP-MS | 35.03 | 0.2 |
| Kuleff *et al.* 1984 | INAA | 35.3 | 1.2 |
| Fedorowich *et al.* 1993 | ICP-MS | 35.4 | 0.4 |
| INAA, Toronto (T.S.) | INAA | 35.6 | 0.1 |
| ICP-MS, BGS (T.S.) | ICP-MS | 35.95 | 1.21 |
| NIST * | NIST | 36 | |
| Chen *et al.* 1993 | SXRF | 36 | |
| Raith *et al.* 1994* | LA-ICP-MS | 36.28 | 0.17 |
| McGinley and Schweikert 1976a | CPAA | 37 | 4 |
| Chenery and Cook 1993 | LA-ICP-MS | 43.6 | |
| Bonham and Quattlebaum 1988 | LA-SSMS | 53 | |
| **Fe** | | | |
| Bendicho and de Loos Vollerbregt 1990a | GFAAS | 37.7 | 9 |
| McGinley and Schweikert 1976a | CPAA | 48 | |
| NIST * | NIST | 51 | 2 |
| Maienthal 1973 | POL | 51.3 | 7 |
| Bendicho and de Loos Vollerbregt 1990b | GFAAS | 53 | 1 |
| Milton and Hutton 1993* | GDMS | 55 | |
| Kuleff *et al.* 1984 | INAA | 60 | 3 |
| Haney 1977 | IDSSMS | 88 | 0.8 |
| ICP-AES, Memorial (T.S.) | ICP-AES | 115 | 10 |
| **Ga** | | | |
| Bonham and Quattlebaum 1988 | LA-SSMS | 33 | |
| ICP-AES, Memorial (T.S.) | ICP-AES | 33.5 | 1.7 |
| Hollocher and Ruiz 1995 | ICP-MS | 34 | 2 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 36.74 | 1.57 |

**Table 7 (continued).**
**Compilation of published and new concentration data (µg g⁻¹) for NIST SRM 612. s = standard deviation. T.S. indicates data from this study, NIST data from the NIST certificate. Those publications marked * are not included in calculations of averages, range and median**

| Element, authors | Method | Conc. | s |
|---|---|---|---|
| **Ga (cont.)** | | | |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 36.88 | 1.08 |
| ICP-MS, BGS (T.S.) | ICP-MS | 38.04 | 2.97 |
| Fedorowich *et al.* 1993 | ICP-MS | 38.3 | 1.2 |
| McGinley and Schweikert 1976a | CPAA | 44 | 10 |
| Joyce and Schweikert 1984 | PIXE | 44.9 | 11 |
| **Gd** | | | |
| Sutton *et al.* 1993 | SXRF | 30 | |
| Jackson *et al.* 1992 | ICP-MS | 35.4 | 3 |
| Gladney *et al.* 1985 | TCGS | 36 | 4 |
| Hollocher and Ruiz 1995 | ICP-MS | 36 | 3 |
| Chen *et al.* 1993 | SXRF | 36 | |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 36.03 | 0.23 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 36.31 | 0.99 |
| Denoyer *et al.* 1991 | LA-ICP-MS | 37 | 2 |
| Pearce *et al.* 1996 | ICP-MS | 37 | |
| ICP-MS sinter, Memorial (T.S.) | ICP-MS | 37.82 | 1.12 |
| McGinley and Schweikert 1976a | CPAA | 38 | 5 |
| Gladney *et al.* 1985 | TCGS | 38 | 4 |
| ICP-MS, BGS (T.S.) | ICP-MS | 38.26 | 1.65 |
| Fedorowich *et al.* 1993 | ICP-MS | 38.5 | 0.8 |
| Raith *et al.* 1994* | LA-ICP-MS | 38.93 | 0.11 |
| NIST * | NIST | 39 | |
| Bonham and Quattlebaum 1988 | LA-SSMS | 61 | |
| **Ge** | | | |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 32.77 | 0.61 |
| Fedorowich *et al.* 1993 | ICP-MS | 36.5 | 1.2 |
| **Hf** | | | |
| Bonham and Quattlebaum 1988 | LA-SSMS | 12 | |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 26.43 | 0.98 |
| Kuleff *et al.* 1984 | INAA | 32.2 | 1.6 |
| McGinley and Schweikert 1976a | CPAA | 35 | 4 |
| Hollocher and Ruiz 1995 | ICP-MS | 35 | 3 |
| INAA, Toronto (T.S.) | INAA | 35 | 0.1 |
| ICP-MS sinter, Memorial (T.S.) | ICP-MS | 35.9 | 0.6 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 36.99 | 0.67 |
| Jackson *et al.* 1992 | ICP-MS | 37.6 | 1 |
| Fedorowich *et al.* 1993 | ICP-MS | 38.8 | 0.9 |
| Kim and Born 1973 | INAA | 52.29 | 3.11 |
| **Ho** | | | |
| Bonham and Quattlebaum 1988 | LA-SSMS | 30 | |
| Hollocher and Ruiz 1995 | ICP-MS | 36 | 3 |
| Raith *et al.* 1994* | LA-ICP-MS | 36.93 | 0.34 |
| Sutton *et al.* 1993 | SXRF | 37 | |
| Jackson *et al.* 1992 | ICP-MS | 37.3 | 1.2 |
| ICP-MS sinter, Memorial (T.S.) | ICP-MS | 37.3 | 0.5 |
| Fedorowich *et al.* 1993 | ICP-MS | 37.6 | 0.7 |
| ICP-MS, BGS (T.S.) | ICP-MS | 38.59 | 1.21 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 38.7 | 0.19 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 38.9 | 0.31 |
| Pearce *et al.* 1996 | ICP-MS | 39.4 | |
| McGinley and Schweikert 1976a | CPAA | 46 | 2 |

| Element, authors | Method | Conc. | s |
|---|---|---|---|
| **In** | | | |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 18.44 | 0.22 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 37.21 | 0.63 |
| Hollocher and Ruiz 1995 | ICP-MS | 41 | 2 |
| ICP-MS, BGS (T.S.) | ICP-MS | 43.43 | 1.87 |
| Bonham and Quattlebaum 1988 | LA-SSMS | 44 | |
| McGinley and Schweikert 1976a | CPAA | 49 | 4 |
| **K** | | | |
| Bonham and Quattlebaum 1988 | LA-SSMS | 59 | |
| NIST * | NIST | 64 | |
| Haney 1977 | IDSSMS | 66 | |
| AAS, Aberystwyth (T.S.) | AAS | 66.52 | 2.01 |
| **La** | | | |
| Hollocher and Ruiz 1995 | ICP-MS | 33 | 3 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 33.45 | 0.35 |
| Pearce *et al.* 1996 | ICP-MS | 33.6 | |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 34.02 | 0.64 |
| ICP-MS sinter, Memorial (T.S.) | ICP-MS | 34.3 | 0.7 |
| INAA, Toronto (T.S.) | INAA | 34.3 | 0.2 |
| ICP-MS, BGS (T.S.) | ICP-MS | 34.63 | 2.09 |
| Sheibley 1973 | INAA | 35 | 15 |
| Imbert and Telouk 1993 * | LA-ICP-MS | 35 | 6 |
| Jackson *et al.* 1992 | ICP-MS | 35.7 | 1.2 |
| Fedorowich *et al.* 1993 | ICP-MS | 35.9 | 0.7 |
| NIST * | NIST | 36 | |
| ICP-AES, Memorial (T.S.) | ICP-AES | 36.9 | 0.6 |
| Sutton *et al.* 1993 | SXRF | 38 | |
| McGinley and Schweikert 1976a | CPAA | 39 | 5 |
| Kuleff *et al.* 1984 | INAA | 40.2 | 1.2 |
| Chen *et al.* 1993 | SXRF | 41 | |
| Chenery and Cook 1993 | LA-ICP-MS | 41.2 | |
| Bonham and Quattlebaum 1988 | LA-SSMS | 48 | |
| **Li** | | | |
| Fedorowich *et al.* 1993 | ICP-MS | 37.9 | 0.1 |
| McGinley and Schweikert 1975 | CPAA | 38 | 4 |
| Jackson *et al.* 1992 | ICP-MS | 39.9 | 4.4 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 40.24 | 1.21 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 40.27 | 1.95 |
| ICP-MS, BGS (T.S.) | ICP-MS | 41.67 | 1.76 |
| Freidli *et al.* 1988b | HIAA | 42 | 11 |
| Freidli *et al.* 1987 | HIAA | 42 | 3 |
| Freidli *et al.* 1988a | HIAA | 43 | 6 |
| Lass *et al.* 1982 | HIAA | 44 | 8 |
| Rio *et al.* 1995 | NMP | 48 | 10 |
| Bonham and Quattlebaum 1988 | LA-SSMS | 61 | |
| **Lu** | | | |
| Bonham and Quattlebaum 1988 | LA-SSMS | 29 | |
| Hollocher and Ruiz 1995 | ICP-MS | 35 | 3 |
| ICP-MS sinter, Memorial (T.S.) | ICP-MS | 35.19 | 0.1 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 36.51 | 0.5 |
| ICP-MS, BGS (T.S.) | ICP-MS | 36.72 | 0.99 |

Table 7 (continued).
**Compilation of published and new concentration data (µg g-1) for NIST SRM 612. s = standard deviation. T.S. indicates data from this study, NIST data from the NIST certificate. Those publications marked * are not included in calculations of averages, range and median**

| Element, authors | Method | Conc. | s |
|---|---|---|---|
| **Lu (cont.)** | | | |
| Kuleff *et al.* 1984 | INAA | 36.8 | 0.2 |
| Raith *et al.* 1994* | LA-ICP-MS | 36.85 | 0.24 |
| Jackson *et al.* 1992 | ICP-MS | 37.2 | 1.8 |
| Fedorowich *et al.* 1993 | ICP-MS | 37.5 | 0.5 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 39.5 | 0.25 |
| Sutton *et al.* 1993 | SXRF | 40 | |
| INAA, Toronto (T.S.) | INAA | 40 | 0.1 |
| Pearce *et al.* 1996 | ICP-MS | 40.4 | |
| McGinley and Schweikert 1976a | CPAA | 45 | 4 |
| **Mg** | | | |
| Bonham and Quattlebaum 1988 | LA-SSMS | 36 | |
| Fedorowich *et al.* 1993 | ICP-MS | 70.9 | 1.1 |
| ICP-MS, BGS (T.S.) | ICP-MS | 75.21 | 14.51 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 85.09 | 4.37 |
| Jackson *et al.* 1992 | ICP-MS | 120 | 60 |
| Kanda *et al.* 1980 | IPAA | 341 | 16 |
| **Mn** | | | |
| Bonham and Quattlebaum 1988 | LA-SSMS | 22 | |
| ICP-AES, Memorial (T.S.) | ICP-AES | 36.8 | 1.7 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 37.37 | 1.19 |
| Kuleff *et al.* 1984 | INAA | 38.2 | 1.1 |
| Bendicho and de Loos Vollerbregt 1990a | GFAAS | 38.3 | 1.5 |
| Bendicho and de Loos Vollerbregt 1990b | GFAAS | 38.8 | 0.5 |
| Kanda *et al.* 1980 | IPAA | 39 | 2.6 |
| ICP-MS, BGS (T.S.) | ICP-MS | 39.03 | 6.16 |
| NIST * | NIST | 39.6 | 0.8 |
| Raith *et al.* 1994* | LA-ICP-MS | 39.78 | 0.27 |
| Fedorowich *et al.* 1993 | ICP-MS | 39.9 | 0.8 |
| Imbert and Telouk 1993 * | LA-ICP-MS | 46 | 6 |
| **Mo** | | | |
| Jackson *et al.* 1992 | ICP-MS | 33.8 | 2.9 |
| ICP-MS, Memorial (T.S.) | ICP-MS | 34 | 3 |
| Fedorowich *et al.* 1993 | ICP-MS | 36.3 | 2.1 |
| Hollocher and Ruiz 1995 | ICP-MS | 36.9 | 0.4 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 38.61 | 1.24 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 39.68 | 0.92 |
| McGinley and Schweikert 1976a | CPAA | 40 | 5 |
| Bonham and Quattlebaum 1988 | LA-SSMS | 43 | |
| **Nb** | | | |
| Bonham and Quattlebaum 1988 | LA-SSMS | 35 | |
| Raith *et al.* 1994* | LA-ICP-MS | 36.57 | 0.23 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 37.18 | 0.39 |
| Kanda *et al.* 1980 | IPAA | 38.1 | 1 |
| Jackson *et al.* 1992 | ICP-MS | 38.9 | 0.7 |
| Fedorowich *et al.* 1993 | ICP-MS | 44.5 | 1.5 |
| **Nd** | | | |
| Sutton *et al.* 1993 | SXRF | 31 | |
| Denoyer *et al.* 1991 | LA-ICP-MS | 33.3 | 1.5 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 33.52 | 0.48 |
| Jackson *et al.* 1992 | ICP-MS | 34.6 | 2.4 |
| **Nd (cont.)** | | | |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 34.73 | 0.52 |
| Pearce *et al.* 1996 | ICP-MS | 34.9 | |
| Hollocher and Ruiz 1995 | ICP-MS | 35 | 4 |
| ICP-MS sinter, Memorial (T.S.) | ICP-MS | 35.2 | 0.3 |
| NIST * | NIST | 36 | |
| Chen *et al.* 1993 | SXRF | 36 | |
| Raith *et al.* 1994* | LA-ICP-MS | 36.16 | 0.18 |
| ICP-MS, BGS (T.S.) | ICP-MS | 36.17 | 1.21 |
| Fedorowich *et al.* 1993 | ICP-MS | 37.3 | 0.7 |
| Chenery and Cook 1993 | LA-ICP-MS | 41.1 | |
| Bonham and Quattlebaum 1988 | LA-SSMS | 65 | |
| **Ni** | | | |
| Bonham and Quattlebaum 1988 | LA-SSMS | 15 | |
| ICP-AES, Memorial (T.S.) | ICP-AES | 29.2 | 0.5 |
| Milton and Hutton 1993* | GDMS | 32 | |
| Bendicho and de Loos Vollerbregt 1990a | GFAAS | 37.6 | 2 |
| Fedorowich *et al.* 1993 | ICP-MS | 37.8 | 1.9 |
| Raith *et al.* 1994* | LA-ICP-MS | 37.89 | 0.38 |
| Bendicho and de Loos Vollerbregt 1990b | GFAAS | 38.6 | 0.4 |
| NIST * | NIST | 38.8 | 0.2 |
| Kanda *et al.* 1980 | IPAA | 40.1 | 1.1 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 42.32 | 1.53 |
| ICP-MS, BGS (T.S.) | ICP-MS | 43.43 | 5.61 |
| **P** | | | |
| ICP-AES, Memorial (T.S.) | ICP-AES | 39.1 | 0.6 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 71.21 | 21.7 |
| **Pb** | | | |
| McGinley and Schweikert 1976a | CPAA | 33 | 5 |
| Imbert and Telouk 1993 * | LA-ICP-MS | 35 | 5 |
| Headridge and Riddington 1984 | GFAAS | 36.33 | 1.25 |
| Jackson *et al.* 1992 | ICP-MS | 36.6 | 3.6 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 36.96 | 7.98 |
| Fisher 1986 | IDMS | 38.37 | 0.13 |
| Gulson 1977 | IDMS | 38.56 | 0.09 |
| Barnes *et al.* 1973 | IDMS | 38.56 | 0.07 |
| NIST * | NIST | 38.57 | 0.2 |
| Barnes *et al.* 1973 | IDMS | 38.57 | 0.09 |
| Vargas *et al.* 1987 | HeAA | 38.7 | 3.9 |
| Broekman and van Raaphorst 1983 | IDMS | 38.83 | 0.09 |
| Bonham and Quattlebaum 1988 | LA-SSMS | 39 | |
| Haney 1977 | IDSSMS | 39.5 | |
| Grey 1990 | AAS | 41 | 2.3 |
| ICP-MS, BGS (T.S.) | ICP-MS | 41.67 | 4.4 |
| Denoyer *et al.* 1991 | LA-ICP-MS | 42.8 | 1.1 |
| Milton and Hutton 1993* | GDMS | 45 | |
| Fedorowich *et al.* 1993 | ICP-MS | 57.9 | 1.8 |
| Raith *et al.* 1994* | LA-ICP-MS | 73.99 | 2.68 |
| **Pr** | | | |
| Sutton *et al.* 1993 | SXRF | 33 | |
| Pearce *et al.* 1996 | ICP-MS | 34.7 | |

GEOSTANDARDS NEWSLETTER
The Journal of Geostandards and Geoanalysis

Table 7 (continued).
Compilation of published and new concentration data (µg g$^{-1}$) for NIST SRM 612. s = standard deviation. T.S. indicates data from this study, NIST data from the NIST certificate. Those publications marked * are not included in calculations of averages, range and median

| Element, authors | Method | Conc. | s |
|---|---|---|---|
| **Pr (cont.)** | | | |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 35.9 | 0.2 |
| McGinley and Schweikert 1976a | CPAA | 36 | 4 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 37.01 | 0.73 |
| Raith *et al.* 1994* | LA-ICP-MS | 37.04 | 0.21 |
| Jackson *et al.* 1992 | ICP-MS | 37.4 | 0.8 |
| ICP-MS sinter, Memorial (T.S.) | ICP-MS | 37.62 | 0.19 |
| ICP-MS, BGS (T.S.) | ICP-MS | 37.82 | 1.43 |
| Fedorowich *et al.* 1993 | ICP-MS | 38.4 | 0.8 |
| Bonham and Quattlebaum 1988 | LA-SSMS | 39 | |
| **Rb** | | | |
| Raith *et al.* 1994* | LA-ICP-MS | 29.14 | 0.59 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 31.02 | 0.14 |
| Jackson *et al.* 1992 | ICP-MS | 31.1 | 0.4 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 31.29 | 0.69 |
| Fedorowich *et al.* 1993 | ICP-MS | 31.3 | 0.8 |
| NIST * | NIST | 31.4 | 0.4 |
| Lippolt *et al.* 1983 | IDMS | 31.41 | 0.08 |
| Moore *et al.* 1973 | IDMS | 31.44 | 0.31 |
| Haney 1977 | IDSSMS | 31.7 | |
| Kanda *et al.* 1980 | IPAA | 32 | 1.4 |
| Hollocher and Ruiz 1995 | ICP-MS | 32 | 2 |
| INAA, Toronto (T.S.) | INAA | 33 | 5 |
| Bonham and Quattlebaum 1988 | LA-SSMS | 34 | |
| Kuleff *et al.* 1984 | INAA | 36 | 4 |
| Milton and Hutton 1993* | GDMS | 39 | |
| **Re** | | | |
| Hollocher and Ruiz 1995 | ICP-MS | 5.8 | 0.5 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 10.43 | 0.67 |
| **S** | | | |
| Bonham and Quattlebaum 1988 | LA-SSMS | 16 | |
| **Sb** | | | |
| Kuleff *et al.* 1984 | INAA | 32.2 | 1.6 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 32.27 | 0.91 |
| Fedorowich *et al.* 1993 | ICP-MS | 34.9 | 1.7 |
| McGinley and Schweikert 1976a | CPAA | 38 | 2 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 38.91 | 0.4 |
| Kanda *et al.* 1980 | IPAA | 39.4 | 0.3 |
| Bonham and Quattlebaum 1988 | LA-SSMS | 41 | |
| Kim and Born 1973 | INAA | 45.2 | 6.74 |
| **Sc** | | | |
| Kuleff *et al.* 1984 | INAA | 34 | 3 |
| Hollocher and Ruiz 1995 | ICP-MS | 34.4 | 0.4 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 37.88 | 0.47 |
| Kanda *et al.* 1980 | IPAA | 38.2 | 1.2 |
| Kim and Born 1973 | INAA | 40.35 | 0.35 |
| ICP-AES, Memorial (T.S.) | ICP-AES | 40.8 | 0.7 |
| ICP-MS, Memorial (T.S.) | ICP-MS | 48 | 13 |
| Kobayashi 1986 | NAA | 52 | 6 |
| Fedorowich *et al.* 1993 | ICP-MS | 54.6 | 0.7 |

| Element, authors | Method | Conc. | s |
|---|---|---|---|
| **Sm** | | | |
| Gladney *et al.* 1985 | TCGS | 32.7 | 3 |
| Gladney *et al.* 1985 | TCGS | 32.8 | 3 |
| Sutton *et al.* 1993 | SXRF | 34 | |
| Hollocher and Ruiz 1995 | ICP-MS | 35 | 3 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 35.62 | 0.18 |
| Denoyer *et al.* 1991 | LA-ICP-MS | 35.8 | 1.3 |
| ICP-MS sinter, Memorial (T.S.) | ICP-MS | 36.4 | 0.4 |
| Pearce *et al.* 1996 | ICP-MS | 36.5 | |
| Jackson *et al.* 1992 | ICP-MS | 36.8 | 1.4 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 37.01 | 0.49 |
| Fedorowich *et al.* 1993 | ICP-MS | 37.1 | 0.8 |
| ICP-MS, BGS (T.S.) | ICP-MS | 37.49 | 1.32 |
| INAA, Toronto (T.S.) | INAA | 38.5 | 0.1 |
| NIST * | NIST | 39 | |
| Raith *et al.* 1994* | LA-ICP-MS | 39 | 0.31 |
| Chen *et al.* 1993 | SXRF | 39 | |
| Kuleff *et al.* 1984 | INAA | 39.6 | 1.1 |
| Chenery and Cook 1993 | LA-ICP-MS | 43.2 | |
| Bonham and Quattlebaum 1988 | LA-SSMS | 67 | |
| **Sn** | | | |
| Bonham and Quattlebaum 1988 | LA-SSMS | 16 | |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 36.21 | 1.83 |
| Fedorowich *et al.* 1993 | ICP-MS | 36.8 | 0.4 |
| ICP-MS, BGS (T.S.) | ICP-MS | 38.81 | 2.2 |
| McGinley and Schweikert 1976a | CPAA | 40 | 4 |
| **Sr** | | | |
| McGinley and Schweikert 1976a | CPAA | 72 | 6 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 72.96 | 0.46 |
| Imbert and Telouk 1993 * | LA-ICP-MS | 73.2 | 5 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 73.56 | 1.26 |
| ICP-AES, Memorial (T.S.) | ICP-AES | 73.9 | 0.5 |
| Denoyer *et al.* 1991 | LA-ICP-MS | 74.1 | 3.3 |
| Jackson *et al.* 1992 | ICP-MS | 75.3 | 1.1 |
| Haney 1977 | IDSSMS | 76.3 | |
| Kanda *et al.* 1980 | IPAA | 77.3 | 1.3 |
| Bonham and Quattlebaum 1988 | LA-SSMS | 78 | |
| Lippolt *et al.* 1983 | IDMS | 78.31 | 0.09 |
| Moore *et al.* 1973 | IDMS | 78.38 | 0.25 |
| NIST * | NIST | 78.4 | 0.2 |
| Raith *et al.* 1994* | LA-ICP-MS | 78.66 | 0.42 |
| Fedorowich *et al.* 1993 | ICP-MS | 79.5 | 3 |
| Denoyer 1990 | LA-ICP-MS | 86.2 | 3.1 |
| Milton and Hutton 1993* | GDMS | 92 | |
| **Ta** | | | |
| Raith *et al.* 1994* | LA-ICP-MS | 33.66 | 0.32 |
| Kim and Born 1973 | INAA | 36.33 | 5.6 |
| Jackson *et al.* 1992 | ICP-MS | 39.3 | 0.5 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 40.51 | 0.65 |
| Fedorowich *et al.* 1993 | ICP-MS | 40.7 | 0.7 |
| INAA, Toronto (T.S.) | INAA | 42 | 0.5 |
| Kuleff *et al.* 1984 | INAA | 52.7 | 0.3 |

Table 7 (continued).
Compilation of published and new concentration data (µg g-1) for NIST SRM 612. s = standard deviation. T.S. indicates data from this study, NIST data from the NIST certificate. Those publications marked * are not included in calculations of averages, range and median

| Element, authors | Method | Conc. | s |
|---|---|---|---|
| **Tb** | | | |
| Kuleff *et al.* 1984 | INAA | 22 | 2 |
| Bonham and Quattlebaum 1988 | LA-SSMS | 31 | |
| Sutton *et al.* 1993 | SXRF | 31 | |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 34 | 0.81 |
| ICP-MS sinter, Memorial (T.S.) | ICP-MS | 35.44 | 0 |
| Hollocher and Ruiz 1995 | ICP-MS | 36 | 3 |
| Fedorowich *et al.* 1993 | ICP-MS | 36.7 | 0.9 |
| Jackson *et al.* 1992 | ICP-MS | 36.9 | 0.9 |
| Kobayashi 1986 | NAA | 37 | 2 |
| ICP-MS, BGS (T.S.) | ICP-MS | 37.16 | 1.21 |
| INAA, Toronto (T.S.) | INAA | 38.3 | 0.1 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 38.46 | 0.24 |
| Pearce *et al.* 1996 | ICP-MS | 39.1 | |
| Raith *et al.* 1994* | LA-ICP-MS | 39.52 | 0.27 |
| Kim and Born 1973 | INAA | 52.9 | 5.62 |
| **Th** | | | |
| Bonham and Quattlebaum 1988 | LA-SSMS | 23 | |
| Sheibley 1973 | INAA | 31 | 1 |
| Kuleff *et al.* 1984 | INAA | 36 | 2 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 36.6 | 0.62 |
| Jackson *et al.* 1992 | ICP-MS | 36.7 | 1.6 |
| ICP-MS, BGS (T.S.) | ICP-MS | 36.83 | 1.76 |
| Denoyer *et al.* 1991 | LA-ICP-MS | 36.9 | 2.1 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 37.08 | 0.33 |
| Fedorowich *et al.* 1993 | ICP-MS | 37.5 | 0.4 |
| Barnes *et al.* 1973 | IDMS | 37.55 | 0.04 |
| NIST * | NIST | 37.79 | 0.08 |
| Barnes *et al.* 1973 | IDMS | 37.79 | 0.017 |
| INAA, Toronto (T.S.) | INAA | 38.1 | 0.3 |
| Kim and Born 1973 | INAA | 38.43 | 0.42 |
| Raith *et al.* 1994 | LA-ICP-MS | 39.62 | 0.19 |
| Denoyer 1990 | LA-ICP-MS | 42.1 | 1.3 |
| **Ti** | | | |
| INAA, Toronto (T.S.) | INAA | 38.2 | 0.2 |
| Hollocher and Ruiz 1995 | ICP-MS | 38.6 | 0.4 |
| Imbert and Telouk 1993 * | LA-ICP-MS | 44 | 6.8 |
| Fedorowich *et al.* 1993 | ICP-MS | 45.4 | 2.3 |
| ICP-AES, Memorial (T.S.) | ICP-AES | 45.7 | 1.8 |
| Maienthal 1973 | POL | 50 | 0.3 |
| NIST * | NIST | 50.1 | 0.8 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 51.35 | 6.65 |
| Kanda *et al.* 1980 | IPAA | 55.2 | 8.3 |
| Bonham and Quattlebaum 1988 | LA-SSMS | 57 | |
| **Tl** | | | |
| Bonham and Quattlebaum 1988 | LA-SSMS | 7 | |
| McGinley and Schweikert 1976a | CPAA | 14 | 0.3 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 14.69 | 0.26 |
| Jackson *et al.* 1992 | ICP-MS | 14.8 | 0.1 |
| Milton and Hutton 1993* | GDMS | 15 | 1.8 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 15.02 | 0.51 |

| Element, authors | Method | Conc. | s |
|---|---|---|---|
| **Tl (cont.)** | | | |
| ICP-MS, BGS (T.S.) | ICP-MS | 15.28 | 0.66 |
| Barnes *et al.* 1973 | IDMS | 15.68 | 3 |
| NIST * | NIST | 15.7 | |
| Fedorowich *et al.* 1993 | ICP-MS | 16 | 0.3 |
| **Tm** | | | |
| Sutton *et al.* 1993 | SXRF | 30 | |
| Bonham and Quattlebaum 1988 | LA-SSMS | 32 | |
| Hollocher and Ruiz 1995 | ICP-MS | 36 | 3 |
| ICP-MS sinter, Memorial (T.S.) | ICP-MS | 36.2 | 0.4 |
| ICP-MS, BGS (T.S.) | ICP-MS | 36.72 | 1.43 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 37.29 | 0.63 |
| Jackson *et al.* 1992 | ICP-MS | 37.3 | 2.6 |
| Raith *et al.* 1994* | LA-ICP-MS | 38.6 | 0.19 |
| Fedorowich *et al.* 1993 | ICP-MS | 38.7 | 0.6 |
| Pearce *et al.* 1996 | ICP-MS | 39 | |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 39.15 | 0.29 |
| **U** | | | |
| Bonham and Quattlebaum 1988 | LA-SSMS | 30 | |
| Denoyer *et al.* 1991 | LA-ICP-MS | 31.8 | 4.1 |
| INAA, Toronto (T.S.) | INAA | 35 | 0.5 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 35.39 | 0.22 |
| Virk 1980 | NTM | 35.74 | |
| Conrad *et al.* 1982 | DNAA | 36.3 | 7.2 |
| Jackson *et al.* 1992 | ICP-MS | 36.9 | 1.7 |
| Carpenter 1972 | NTM | 36.94 | 0.83 |
| Fedorowich *et al.* 1993 | ICP-MS | 37.1 | 0.5 |
| Fisher 1986 | IDMS | 37.37 | 0.064 |
| Barnes *et al.* 1973 | IDMS | 37.37 | 0.015 |
| NIST * | NIST | 37.38 | 0.08 |
| ICP-MS, BGS (T.S.) | ICP-MS | 37.38 | 1.43 |
| Carpenter 1972 | NTM | 37.39 | 0.09 |
| Carpenter 1972 | NTM | 37.41 | 0.21 |
| Barnes *et al.* 1973 | IDMS | 37.41 | 0.09 |
| Gulson 1977 | IDMS | 37.66 | 0.08 |
| Raith *et al.* 1994* | LA-ICP-MS | 37.7 | 0.41 |
| Conrad *et al.* 1982 | DNAA | 39 | 4.9 |
| Gladney *et al.* 1984 | TCGS | 40 | 2 |
| Kuleff *et al.* 1984 | INAA | 43.6 | 1.6 |
| Denoyer 1990 | LA-ICP-MS | 44.1 | 1.8 |
| **V** | | | |
| Bonham and Quattlebaum 1988 | LA-SSMS | 32 | |
| Hollocher and Ruiz 1995 | ICP-MS | 35.1 | 0.3 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 36.16 | 0.57 |
| ICP-AES, Memorial (T.S.) | ICP-AES | 36.6 | 0.5 |
| Jackson *et al.* 1992 | ICP-MS | 37.6 | 0.3 |
| Fedorowich *et al.* 1993 | ICP-MS | 38.6 | 0.5 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 41.44 | 6.49 |
| Joyce and Schweikert 1984 | PIXE | 42 | 4.2 |
| Raith *et al.* 1994* | LA-ICP-MS | 45.7 | 0.29 |
| ICP-MS, BGS (T.S.) | ICP-MS | 46.29 | 7.59 |
| Kuleff *et al.* 1984 | INAA | 58.6 | 6 |

**Table 7 (continued).**
**Compilation of published and new concentration data (µg g⁻¹) for NIST SRM 612. s = standard deviation. T.S. indicates data from this study, NIST data from the NIST certificate. Those publications marked * are not included in calculations of averages, range and median**

| Element, authors | Method | Conc. | s |
|---|---|---|---|
| **W** | | | |
| ICP-MS, Memorial (T.S.) | ICP-MS | 26.5 | |
| McGinley and Schweikert 1976a | CPAA | 39 | 4 |
| Fedorowich *et al.* 1993 | ICP-MS | 40.1 | 1.2 |
| **Y** | | | |
| Raith *et al.* 1994* | LA-ICP-MS | 25.54 | 0.25 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 31.45 | 0.73 |
| ICP-MS sinter, Memorial (T.S.) | ICP-MS | 35.2 | 0.5 |
| Jackson *et al.* 1992 | ICP-MS | 36.6 | 0.6 |
| Hollocher and Ruiz 1995 | ICP-MS | 36.7 | 0.4 |
| Fedorowich *et al.* 1993 | ICP-MS | 36.8 | 1.2 |
| Kanda *et al.* 1980 | IPAA | 37.9 | 1.4 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 38.96 | 0.77 |
| McGinley and Schweikert 1976a | CPAA | 40 | 5 |
| ICP-AES, Memorial (T.S.) | ICP-AES | 40.4 | 0.5 |
| ICP-MS, BGS (T.S.) | ICP-MS | 41.67 | 3.08 |
| Bonham and Quattlebaum 1988 | LA-SSMS | 46 | |
| **Yb** | | | |
| NIST * | NIST | 42 | |
| Sutton *et al.* 1993 | SXRF | 34 | |
| Hollocher and Ruiz 1995 | ICP-MS | 36 | 3 |
| ICP-MS sinter, Memorial (T.S.) | ICP-MS | 37.1 | 0.3 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 37.43 | 0.38 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 37.5 | 0.98 |
| McGinley and Schweikert 1976a | CPAA | 38 | |
| Jackson *et al.* 1992 | ICP-MS | 38.1 | 2.2 |
| Fedorowich *et al.* 1993 | ICP-MS | 38.9 | 0.2 |
| Kuleff *et al.* 1984 | INAA | 40 | 7.15 |
| ICP-MS, BGS (T.S.) | ICP-MS | 40.02 | 0.99 |
| Chen *et al.* 1993 | SXRF | 42 | |

| Element, authors | Method | Conc. | s |
|---|---|---|---|
| **Yb (cont.)** | | | |
| INAA, Toronto (T.S.) | INAA | 42.4 | 0.5 |
| Pearce *et al.* 1996 | ICP-MS | 42.7 | |
| Raith *et al.* 1994* | LA-ICP-MS | 42.86 | 0.27 |
| Kobayashi 1986 | NAA | 44 | 3 |
| Chenery and Cook 1993 | LA-ICP-MS | 45.2 | |
| Bonham and Quattlebaum 1988 | LA-SSMS | 52 | |
| Kim and Born 1973 | INAA | 55 | 5 |
| **Zn** | | | |
| Bonham and Quattlebaum 1988 | LA-SSMS | 13 | |
| Raith *et al.* 1994* | LA-ICP-MS | 13.65 | 0.9 |
| Hollocher and Ruiz 1995 | ICP-MS | 34.1 | 0.1 |
| ICP-AES, Memorial (T.S.) | ICP-AES | 35 | 0.8 |
| AAS, Aberystwyth (T.S.) | AAS | 35.48 | 2.36 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 38.81 | 3.2 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 39.83 | 1.05 |
| ICP-MS, BGS (T.S.) | ICP-MS | 44.31 | 4.18 |
| Fedorowich *et al.* 1993 | ICP-MS | 49.4 | 1.7 |
| **Zr** | | | |
| ICP-MS sinter, Memorial (T.S.) | ICP-MS | 33.81 | 0.04 |
| ICP-MS, Aberystwyth (T.S.) | ICP-MS | 34.84 | 1.31 |
| Jackson *et al.* 1992 | ICP-MS | 35.2 | 1 |
| ICP-MS, Notre Dame (T.S.) | ICP-MS | 35.23 | 0.025 |
| Hollocher and Ruiz 1995 | ICP-MS | 37.3 | 0.4 |
| ICP-AES, Memorial (T.S.) | ICP-AES | 37.4 | 0.3 |
| Kanda *et al.* 1980 | IPAA | 41.8 | 1.1 |
| Bonham and Quattlebaum 1988 | LA-SSMS | 43 | |
| Fedorowich *et al.* 1993 | ICP-MS | 43.5 | 5.2 |
| Raith *et al.* 1994* | LA-ICP-MS | 46.31 | 0.18 |

standard analytical techniques - many of the analyses for B in these glasses fall into this category for example; (iii) data generated as part of a larger study of other materials, such as geologic or forensic studies. Whilst we have searched the literature extensively for information on these glasses, data "hidden" in other studies may have been overlooked, and our compilation may not be exhaustive. We would welcome copies of any further information that is not included in the reference list. Only eight publications produce data for more than fifteen elements in NIST SRM 610, and only nine for NIST SRM 612. Only these larger studies are discussed here, information concerning studies of fewer elements can be inferred from the reference list or compilation tables.

One of the earliest extensive studies on NIST SRM 610 was that of Bergholz (1974) who used mass spectrometric methods to determine twenty four elements. NIST SRM 610 and NIST SRM 612 were analysed by McGinley and Schweikert (1976), who determined up to twenty six elements of Z $\geq$ 26 using energy dispersive X-ray counting of radioactive species created in the samples by 20 MeV proton and deuteron bombardment.

Haney (1977), in an extensive study of glasses for use in forensic science produced analyses of fifty seven elements in NIST SRM 612 by isotope dilution mass spectrometry. Kanda et al. (1980) produced analyses of fifteen elements in NIST SRM 612 by instrumental photon activation analysis, and in the same material Kuleff (1984) determined twenty five trace elements by INAA. Rogers et al. (1987) produced data for a total of forty nine elements in NIST SRM 610 using a PIXE method. Spectra were obtained by bombardment of the sample with Be or Al ions at differing beam energies,

GEOSTANDARDS NEWSLETTER
The Journal of Geostandards and Geoanalysis

Table 8.
Summary of composition data (µg g-1) for NIST SRM 610. N = total number of analyses included in calculation of average, range, geometric mean and median (published and this study). Overall average = average of all analyses (combining published data and new data presented in this study)) excluding semi-quantitative analyses and analyses with "circular calibrations" (see text). s = standard deviation. Range = maximum and minimum concentrations . Median = median of all data. Geometric mean = geometric mean of all data. Preferred average = average of those analyses within ± 1 standard deviation of the overall average. n = number of analyses included in preferred average. $s_p$ = standard deviation of preferred average. NIST = NIST certified values (open) and information values (in brackets)

| | N | Overall average | s | Range Max | Range Min | Median | Geometric mean | Preferred average | $s_p$ | n | NIST | cl* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ag | 8 | 235.4 | 29.0 | 267 | 180 | 238.5 | 233.7 | 239.4 | 18.6 | 6 | (254) | 10 | Ag |
| As | 7 | 330.1 | 35.4 | 406 | 303 | 317 | 328.6 | 317.4 | 12.4 | 6 | | | As |
| Au | 7 | 22.7 | 5.3 | 31 | 15.63 | 22.6 | 22.2 | 22.5 | 3.5 | 5 | (25) | | Au |
| B | 9 | 332.4 | 72.1 | 368 | 141 | 356 | 321.4 | 356.4 | 7.3 | 8 | (351) | | B |
| Ba | 9 | 565.1 | 285.5 | 1160 | 382 | 424 | 518.3 | 424.1 | 29.3 | 7 | | | Ba |
| Be | 9 | 469.0 | 34.9 | 540.67 | 421 | 452 | 467.9 | 465.6 | 19.2 | 7 | | | Be |
| Bi | 10 | 326.4 | 99.7 | 430 | 113.7 | 372.5 | 307.0 | 357.7 | 49.0 | 7 | | | Bi |
| Cd | 6 | 269.6 | 67.1 | 393 | 187 | 259 | 263.2 | 259.4 | 4.7 | 4 | | | Cd |
| Ce | 12 | 462.6 | 57.6 | 611 | 384 | 451.1 | 459.6 | 447.8 | 16.8 | 9 | | | Ce |
| Cl | 2 | 470.0 | 0.0 | 470 | 470 | 470 | 470.0 | 470.0 | 0.0 | 2 | | | Cl |
| Co | 14 | 374.8 | 82.8 | 444 | 135 | 396.5 | 361.6 | 405.0 | 22.9 | 12 | (390) | | Co |
| Cr | 9 | 415.0 | 49.5 | 485 | 343 | 406 | 412.4 | 405.2 | 32.3 | 6 | | | Cr |
| Cs | 7 | 429.4 | 191.3 | 840 | 259 | 369 | 401.9 | 360.9 | 67.5 | 6 | | | Cs |
| Cu | 13 | 421.7 | 42.0 | 486 | 343 | 428 | 419.7 | 430.3 | 23.6 | 10 | (444) | 4 | Cu |
| Dy | 7 | 420.2 | 39.9 | 466 | 343 | 429 | 418.5 | 426.5 | 18.0 | 5 | | | Dy |
| Er | 9 | 440.1 | 54.8 | 526 | 360 | 436 | 437.2 | 426.0 | 23.9 | 6 | | | Er |
| Eu | 9 | 479.6 | 110.1 | 731 | 357 | 442.7 | 469.9 | 461.1 | 52.1 | 7 | | | Eu |
| Fe | 11 | 430.3 | 79.3 | 517 | 260 | 455 | 422.2 | 457.1 | 22.2 | 8 | 458 | 9 | Fe |
| Ga | 11 | 443.8 | 28.7 | 501.3 | 395 | 436.5 | 443.0 | 438.1 | 11.3 | 8 | | | Ga |
| Gd | 9 | 437.2 | 69.6 | 556 | 331 | 430.53 | 432.4 | 419.9 | 25.2 | 6 | | | Gd |
| Ge | 5 | 433.3 | 38.8 | 496 | 391.3 | 426 | 431.9 | 426.3 | 9.5 | 3 | | | Ge |
| Hf | 10 | 419.1 | 50.3 | 477 | 312.7 | 418 | 416.1 | 417.7 | 28.2 | 7 | | | Hf |
| Ho | 8 | 445.7 | 46.4 | 511 | 358 | 444.9 | 443.5 | 449.4 | 24.6 | 6 | | | Ho |
| In | 7 | 423.9 | 54.7 | 474 | 319 | 449 | 420.5 | 441.4 | 32.0 | 6 | | | In |
| K | 6 | 671.7 | 456.6 | 1600 | 442 | 487.5 | 591.1 | 486.0 | 45.7 | 5 | (461) | | K |
| La | 12 | 509.2 | 138.0 | 794 | 386 | 448 | 494.6 | 457.4 | 72.4 | 10 | | | La |
| Li | 10 | 464.2 | 61.4 | 536.3 | 354 | 487.9 | 460.2 | 484.6 | 21.7 | 7 | | | Li |
| Lu | 11 | 431.0 | 46.9 | 497 | 332 | 440 | 428.6 | 434.7 | 31.0 | 9 | | | Lu |
| Mg | 5 | 465.6 | 37.0 | 511 | 421 | 472 | 464.4 | 465.3 | 26.6 | 3 | | | Mg |
| Mn | 11 | 419.2 | 75.4 | 495 | 216 | 440.8 | 410.9 | 433.3 | 31.8 | 9 | 485 | 10 | Mn |
| Mo | 10 | 363.5 | 57.7 | 427 | 276 | 389.5 | 359.1 | 376.8 | 45.0 | 7 | | | Mo |
| Nb | 8 | 373.7 | 97.8 | 458 | 225 | 428.1 | 360.9 | 419.4 | 57.6 | 6 | | | Nb |
| Nd | 10 | 455.6 | 79.3 | 598 | 364 | 430.6 | 449.8 | 430.8 | 37.5 | 7 | | | Nd |
| Ni | 11 | 437.5 | 74.9 | 603.8 | 316 | 441 | 431.7 | 443.9 | 24.2 | 8 | 458.7 | 4 | Ni |
| P | 2 | 342.5 | 53.1 | 380 | 304.9 | 342.5 | 340.4 | 342.5 | 53.1 | 2 | | | P |
| Pb | 18 | 409.0 | 31.6 | 448 | 301.4 | 417 | 407.7 | 413.3 | 15.4 | 16 | 426 | 1 | Pb |
| Pr | 9 | 432.7 | 57.6 | 505 | 318 | 441 | 429.1 | 429.8 | 30.0 | 6 | | | Pr |
| Rb | 10 | 435.0 | 27.4 | 501.97 | 400 | 429.5 | 434.3 | 431.1 | 11.4 | 8 | 425.7 | 0.8 | Rb |
| Re | 4 | 192.9 | 192.9 | 460.4 | 37 | 137 | 124.3 | 103.7 | 90.0 | 3 | | | Re |
| Sb | 6 | 345.9 | 60.5 | 394 | 233 | 362.2 | 340.7 | 368.5 | 27.5 | 5 | | | Sb |
| Sc | 9 | 432.1 | 47.1 | 486 | 315 | 444 | 429.4 | 441.1 | 9.6 | 7 | | | Sc |
| Se | 3 | 110.7 | 3.1 | 114 | 108 | 110 | 110.6 | 109.0 | 1.4 | 2 | | | Se |
| Sm | 9 | 484.5 | 69.9 | 610 | 417 | 458 | 480.4 | 450.5 | 20.6 | 7 | | | Sm |
| Sn | 5 | 391.3 | 54.5 | 458 | 309.4 | 404 | 388.1 | 396.3 | 17.8 | 3 | | | Sn |
| Sr | 11 | 479.6 | 44.0 | 515.5 | 377 | 498 | 477.6 | 497.4 | 18.3 | 9 | 515.5 | 0.5 | Sr |
| Ta | 11 | 365.9 | 125.7 | 525 | 134 | 340.13 | 342.0 | 376.6 | 77.6 | 7 | | | Ta |
| Tb | 10 | 443.5 | 75.9 | 585 | 328 | 454.9 | 437.6 | 442.8 | 22.4 | 6 | | | Tb |
| Th | 14 | 448.0 | 69.1 | 539 | 249 | 456.3 | 441.8 | 450.6 | 27.8 | 11 | 457.2 | 1.2 | Th |
| Ti | 13 | 428.2 | 66.5 | 524.43 | 257 | 437.3 | 422.6 | 434.0 | 14.7 | 9 | (437) | | Ti |
| Tl | 9 | 61.9 | 5.2 | 70 | 52 | 61.19 | 61.7 | 61.2 | 2.1 | 6 | (61.8) | 2.5 | Tl |
| Tm | 9 | 431.4 | 45.4 | 517 | 366 | 422.6 | 429.3 | 420.1 | 19.2 | 6 | | | Tm |
| U | 17 | 453.2 | 27.3 | 513.3 | 413 | 461.3 | 452.5 | 457.1 | 13.6 | 11 | 461.5 | 1.1 | U |
| V | 12 | 422.1 | 79.3 | 494.2 | 206 | 435.1 | 412.9 | 441.7 | 42.7 | 11 | | | V |
| W | 4 | 425.5 | 44.6 | 467 | 366 | 434.5 | 423.7 | 445.3 | 25.0 | 3 | | | W |
| Y | 10 | 440.2 | 66.9 | 531.47 | 271 | 448 | 434.6 | 449.9 | 19.3 | 8 | | | Y |
| Yb | 9 | 467.2 | 52.2 | 574 | 400 | 450.6 | 464.7 | 461.5 | 30.6 | 7 | | | Yb |
| Zn | 12 | 447.2 | 30.7 | 494.27 | 398 | 451 | 446.3 | 456.3 | 19.2 | 8 | (433) | | Zn |
| Zr | 10 | 435.1 | 26.6 | 482.37 | 381.3 | 435.5 | 434.3 | 439.9 | 7.8 | 7 | | | Zr |

* 95% confidence limits or range, whichever is larger.

Table 9.
Summary of composition data (µg g-1) for NIST SRM 612. Column headings as Table 8

| | N | Overall average | s | Range | | Median | Geometric mean | Preferred average | $s_p$ | n | NIST | cl* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Max | Min | | | | | | | | |
| Ag | 8 | 20.44 | 8.91 | 31 | 1 | 31.26 | 15.46 | 21.92 | 3.26 | 6 | 22 | 0.3 | Ag |
| As | 7 | 38.56 | 11.11 | 58.1 | 25.2 | 35.6 | 37.29 | 37.33 | 6.56 | 5 | | | As |
| Au | 6 | 5.07 | 0.63 | 6 | 4.05 | 5.05 | 5.04 | 5.09 | 0.13 | 4 | (5) | | Au |
| B | 11 | 33.73 | 5.83 | 43 | 25.8 | 33 | 33.26 | 34.73 | 3.21 | 6 | (32) | | B |
| Ba | 11 | 37.92 | 3.42 | 45 | 32.87 | 38 | 37.78 | 37.74 | 1.26 | 7 | (41) | | Ba |
| Be | 10 | 39.31 | 5.88 | 50 | 31 | 38.3 | 38.94 | 37.73 | 2.41 | 7 | | | Be |
| Bi | 6 | 28.73 | 9.86 | 40 | 13 | 32.13 | 26.96 | 29.84 | 5.98 | 4 | | | Bi |
| Cd | 4 | 31.24 | 5.87 | 40 | 27.63 | 28.66 | 30.87 | 28.32 | 0.65 | 3 | | | Cd |
| Ce | 18 | 38.75 | 3.92 | 48.2 | 33 | 38 | 38.57 | 38.35 | 1.64 | 12 | (39) | | Ce |
| Co | 16 | 36.23 | 15.37 | 84 | 2 | 34.95 | 31.05 | 35.26 | 2.44 | 14 | (35.5) | 1.2 | Co |
| Cr | 10 | 51.39 | 39.11 | 155 | 19.241 | 37.97 | 43.19 | 39.88 | 15.17 | 9 | | | Cr |
| Cs | 11 | 46.49 | 16.28 | 95 | 35.08 | 42.3 | 44.81 | 41.64 | 2.59 | 10 | | | Cs |
| Cu | 10 | 35.17 | 11.64 | 52.007 | 6 | 37.57 | 31.63 | 36.71 | 3.07 | 8 | (37.7) | 0.9 | Cu |
| Dy | 14 | 36.03 | 2.22 | 41.7 | 31.1 | 36 | 35.97 | 35.97 | 0.82 | 12 | (35) | | Dy |
| Er | 13 | 37.99 | 3.27 | 44.6 | 32 | 38.15 | 37.86 | 37.43 | 1.50 | 10 | (39) | | Er |
| Eu | 18 | 35.51 | 5.50 | 53 | 26 | 34.97 | 35.16 | 34.44 | 1.59 | 15 | (36) | | Eu |
| Fe | 7 | 64.71 | 27.14 | 115 | 37.7 | 53 | 60.56 | 56.33 | 17.14 | 6 | 51 | 2 | Fe |
| Ga | 9 | 37.71 | 4.29 | 44.9 | 33 | 36.88 | 37.50 | 36.24 | 2.03 | 6 | | | Ga |
| Gd | 15 | 38.09 | 6.66 | 61 | 30 | 37 | 37.66 | 36.95 | 1.06 | 13 | (39) | | Gd |
| Ge | 2 | 34.64 | 2.64 | 36.5 | 32.77 | 34.64 | 34.58 | 34.64 | 2.64 | 2 | | | Ge |
| Hf | 11 | 34.29 | 9.64 | 52.29 | 12 | 35 | 32.61 | 34.77 | 3.65 | 9 | | | Hf |
| Ho | 11 | 37.89 | 3.71 | 46 | 30 | 37.6 | 37.72 | 37.87 | 1.09 | 9 | | | Ho |
| In | 6 | 38.85 | 10.72 | 49 | 18.44 | 42.22 | 37.16 | 42.93 | 4.32 | 5 | | | In |
| K | 3 | 63.84 | 4.20 | 66.52 | 59 | 66 | 63.75 | 66.26 | 0.37 | 2 | (64) | | K |
| La | 17 | 36.95 | 3.92 | 48 | 33 | 35.75 | 36.77 | 35.77 | 2.15 | 13 | (36) | | La |
| Li | 12 | 43.17 | 6.25 | 61 | 37.9 | 41.83 | 42.81 | 41.54 | 2.87 | 11 | | | Li |
| Lu | 13 | 37.60 | 3.73 | 45 | 29 | 37.2 | 37.42 | 37.71 | 1.95 | 11 | | | Lu |
| Mg | 6 | 121.37 | 110.93 | 341 | 36 | 80.15 | 93.51 | 77.44 | 30.15 | 5 | | | Mg |
| Mn | 9 | 36.60 | 5.55 | 39.9 | 22 | 38.3 | 36.11 | 38.43 | 0.99 | 8 | (39.6) | 0.8 | Mn |
| Mo | 8 | 37.79 | 3.15 | 43 | 33.8 | 37.76 | 37.67 | 38.30 | 1.65 | 5 | | | Mo |
| Nb | 5 | 38.74 | 3.54 | 44.5 | 35 | 38.1 | 38.61 | 38.06 | 0.86 | 3 | | | Nb |
| Nd | 13 | 37.52 | 8.58 | 65 | 31 | 35 | 36.86 | 35.24 | 2.44 | 12 | (36) | | Nd |
| Ni | 8 | 35.51 | 9.33 | 3.431 | 15 | 38.2 | 33.96 | 38.44 | 4.64 | 7 | 38.8 | 0.2 | Ni |
| P | 2 | 55.16 | 22.71 | 71.21 | 39.1 | 55.16 | 52.77 | 55.16 | 22.71 | 2 | | | P |
| Pb | 16 | 39.77 | 5.34 | 57.9 | 33 | 38.64 | 39.49 | 38.96 | 1.84 | 14 | 38.57 | 0.2 | Pb |
| Pr | 10 | 36.69 | 1.82 | 39 | 33 | 37.21 | 36.64 | 37.16 | 0.93 | 7 | | | Pr |
| Rb | 12 | 32.19 | 1.48 | 36 | 31.02 | 31.43 | 32.16 | 31.63 | 0.59 | 10 | 31.4 | 0.4 | Rb |
| Re | 2 | 8.12 | 3.27 | 10.43 | 5.8 | 8.12 | 7.78 | 8.12 | 3.27 | 2 | | | Re |
| S | 1 | 16.00 | 0.00 | 16 | 16 | 16 | 16.00 | 16.00 | 16.00 | 1 | | | S |
| Sb | 8 | 37.74 | 4.46 | 45.2 | 32.2 | 38.46 | 37.51 | 38.44 | 2.26 | 5 | | | Sb |
| Sc | 9 | 42.25 | 7.51 | 54.6 | 34 | 40.35 | 41.68 | 41.05 | 4.09 | 5 | | | Sc |
| Sm | 17 | 38.50 | 7.77 | 67 | 32.7 | 36.8 | 37.96 | 36.72 | 2.63 | 16 | (39) | | Sm |
| Sn | 5 | 33.56 | 9.94 | 40 | 16 | 36.8 | 31.91 | 37.96 | 1.76 | 4 | | | Sn |
| Sr | 13 | 76.60 | 3.74 | 86.2 | 72 | 76.3 | 76.52 | 76.15 | 2.29 | 11 | 78.4 | 0.2 | Sr |
| Ta | 6 | 41.92 | 5.62 | 52.7 | 36.33 | 40.61 | 41.64 | 39.77 | 2.15 | 5 | | | Ta |
| Tb | 14 | 36.14 | 6.56 | 52.9 | 22 | 36.8 | 35.58 | 35.92 | 2.68 | 12 | | | Tb |
| Th | 14 | 36.11 | 4.41 | 42.1 | 23 | 36.99 | 35.81 | 37.23 | 0.72 | 11 | 37.79 | 0.08 | Th |
| Ti | 8 | 47.68 | 7.01 | 57 | 38.2 | 47.85 | 47.22 | 48.11 | 3.01 | 4 | (50.1) | 0.8 | Ti |
| Tl | 8 | 14.06 | 2.92 | 16 | 7 | 14.91 | 13.68 | 15.07 | 0.66 | 7 | (15.7) | 0.3 | Tl |
| Tm | 10 | 36.24 | 3.01 | 39.15 | 30 | 37.01 | 36.12 | 37.55 | 1.25 | 8 | | | Tm |
| U | 20 | 37.19 | 3.18 | 44.1 | 30 | 37.37 | 37.06 | 37.15 | 1.23 | 16 | 37.38 | 0.08 | U |
| V | 10 | 40.44 | 7.54 | 58.6 | 32 | 38.1 | 39.88 | 39.22 | 3.76 | 8 | | | V |
| W | 3 | 35.20 | 7.55 | 40.1 | 26.5 | 39 | 34.61 | 39.55 | 0.78 | 2 | | | W |
| Y | 11 | 38.33 | 3.78 | 46 | 31.45 | 37.9 | 38.17 | 38.25 | 2.14 | 9 | | | Y |
| Yb | 17 | 41.20 | 5.52 | 55 | 34 | 40.02 | 40.88 | 39.95 | 2.86 | 14 | (42) | | Yb |
| Zn | 8 | 36.24 | 10.72 | 49.4 | 13 | 37.15 | 34.18 | 37.92 | 3.86 | 6 | | | Zn |
| Zr | 9 | 38.01 | 3.77 | 43.5 | 33.81 | 37.3 | 37.85 | 35.99 | 1.25 | 5 | | | Zr |

* 95% confidence limits or range, whichever is larger.

changes in filter selection producing data of varying quality at different Z ranges. Lukaszew (1990) used a spark source mass spectrometric method to determine the rare earth elements in the NIST SRM 610 glass.

Bonham and Quattlebaum (1989) coupled a Nd:YAG laser to a spark source mass spectrograph to analyse a variety of metals and insulators, including both NIST SRM 610 and NIST SRM 612. They state clearly that, regarding NIST SRM 610, "the sample was not homogeneous", this conclusion being drawn from only four separate analyses and despite their having powdered (and presumably thoroughly mixed) the glass. NIST SRM 612 was also analysed (whether as a powder or the bulk glass is not stated) and their results for most elements "fall well within the predicted factor of three". Notable exceptions include Cu and Ag. Many of the data from Bonham and Quattlebaum disagree wildly with other published data for the NIST glasses, and most of their data are excluded in the calculation of a preferred average by being outside ± 1 standard deviation of the overall mean.

By the early 1990's more work had started to appear on these reference materials, and their potential use as microanalytical standards had been recognised. Hinton (1990), in an ion-microprobe study of silicate glasses, cites chemical data for the NBS-610, assuming all elements to be present at 500 $\mu g\ g^{-1}$ unless analyses from elsewhere were available (e.g. Michael (1988) or NIST certified or estimated concentrations). Hinton (1990) did not produce any new chemical information for NIST SRM 610 and used the actual or assumed values in NBS-610 to calibrate the ion microprobe instrumentation. In many cases substantial errors can occur when the assumed 500 $\mu g\ g^{-1}$ concentrations are used for calibration, although using compilations such as the present one, or with new information on the NIST glasses, corrections can be made retrospectively to published analyses.

Jackson et al. (1992) produced analyses of a range of elements from duplicate ICP-MS analyses of two acid digestions of NIST SRM 612 in a paper dealing with laser ablation ICP-MS. These data include many petrologically significant elements (REE, high field strength, large ion lithophile elements). Powdered samples were analysed using the digestion method of Jenner et al. (1990), which uses a closed bomb $HF/HNO_3$ attack on 0.1 g sample, followed by a double evaporation with $HNO_3$. Final solutions were prepared in dilute $HNO_3$, made up to a given mass (not volume) of solution. For Nb, Mo, Ta and W, a "surrogate calibration" (Jenner et al. 1990) was used where the slope of the Nb and Mo calibrations were determined indirectly from the Zr calibration, and Ta and W from the Hf calibration.

Fedorowich et al. (1993) cited a wide range of solution nebulisation ICP-MS data for NIST SRM 612. Samples were prepared for analysis and their instrument calibrated using a method similar to that of Jenner et al. (1990).

Raith et al. (1996) used a laser ablation ICP-MS technique to determine forty four elements in the NIST SRM 610 and thirty elements in NIST SRM 612. Five spectra were acquired from both the NIST glasses, and three spiked glasses produced by P and H Developments of Glossop U.K. (see above and Hamilton and Hopkins 1995). Calibrations were produced from the first of Raith et al.'s (1996) acquisitions from each standard, using NIST certified or information values and the 75 or 150 $\mu g\ g^{-1}$ concentrations. The remaining four spectra for each standard were then treated as unknowns. It is not surprising that much of Raith et al.'s data is very similar to the NIST information or certified values, and whilst these data show the viability of LA-ICP-MS as a quantitative technique, and demonstrate the linearity of LA-ICP-MS calibrations, the calibration is not against external materials thus these data are not included in the averages given in Tables 8 and 9.

Most recently, Hollocher and Ruiz (1995) produced a suite of new data for NIST SRM 611 (equivalent to NIST SRM 610), NIST SRM 612 and NIST SRM 614 (a nominal 1 $\mu g\ g^{-1}$ reference material). Hollocher and Ruiz (1995) took only one fragment of glass from each sample (weight approximately 150 mg) which was crushed before dissolution of approximately 100 mg in $HF:HNO_3$ in a PTFE bomb, prior to analysis by ICP-MS. Calibration was achieved against synthetic multi element standards, and for NIST SRM 611 and NIST SRM 612, internal standards from the sample were used, followed by normalisation of the data to NIST certified values for Ni, Sr and Pb. It is unclear from the manuscript, how Hollocher and Ruiz (1995) determined their analytical errors (presumably multiple analyses on the single solution prepared of each sample), or how, having only prepared one solution of each sample, they were able to test the statement that "NIST glass SRM's 611, 612 and 614 are nominally homogeneous within expected analytical uncertainty for ...... minor and trace elements on the scale of sampling". Hollocher and Ruiz (1995) quoted maximum, minimum and median concentrations from seventeen publications for NIST SRM 610 and from twenty five publications for NIST SRM 612.

## Summary

In general, the inter-laboratory comparison for the new data presented here is very good, although in some cases the solution nebulisation ICP-MS analyses for some of the light REE are notably lower than data produced in other laboratories (e.g. from Aberystwyth and for some elements from Notre Dame). This phenomenon has also been noted in ICP-MS analysis by Garbe-Schönberg (1993). Nonetheless, the new data compares very favourably with published data presented elsewhere, with the exception of some of the studies mentioned above (e.g. Bonham and Quattlebaum 1989).

There are clearly discrepancies in the analyses of Nb and Ta (and to some extent Zr and Hf), due to problems retaining these elements in solution without HF present. This is evident in both the Aberystwyth and Memorial ICP-MS analyses. These elements are useful petrogenetic indicators and clearly further determinations on these elements are needed.

Several elements present in these glasses have been determined only a small number of times. These include Mg, P, S, Cl, Ge, Se, Cd, Sn, Sb, W and Re. Clearly further determinations of these elements would be of value.

Major element data for NIST SRM 610 and NIST SRM 612 are presented in Tables 1 and 2 which give an average of all the data. When the matrix composition is normalised back to 100%, it compares extremely well with the composition of the matrix given by NIST, although the absolute concentrations of the matrix elements are reduced by the dilution effect of some sixty elements present at nominal 50 µg $g^{-1}$ or 500 µg $g^{-1}$.

Tables 6 and 7 present all the available trace element data for the NIST SRM 610 and NIST SRM 612 glasses. For NIST SRM 610, data is taken from the forty references cited. For NIST SRM 612, data is taken from the forty nine cited references.

All data are summarized in Table 8 (NIST SRM 610) and Table 9 (NIST SRM 612) which includes:
• the overall average and standard deviation for each element,
• the "preferred average" and standard deviation. The preferred average is the average of all values within ± 1 standard deviation of the overall average. Whilst not widely used in the geostandards literature, the preferred average is occasionally reported (see for example Abbey et al. 1979 and Govindaraju 1995), and has the advantage of rejecting some outlying values.
• the range of reported concentrations
• the median
• the geometric mean (calculated after Sankar Das 1979).

All mathematical calculations were performed using the spreadsheet package Microsoft Excel® v5.0. Analyses from Raith et al. (1996) and Imbert and Telouk (1993) were not used to compute results in Tables 8 and 9, the former because data were obtained using a calibration generated from the glasses themselves and the latter because results were reported as being semi-quantitative. In addition, the data presented by Milton and Hutton (1993) has been excluded from the compilations because of a circular calibration strategy. Data from the NIST certificate, being a compilation, is also excluded from the calculations. In most cases, the data of Bonham and Quattlebaum (1989) has been excluded by the rejection process used to calculate the preferred averages, and is clearly distinct from the majority of the data. Otherwise there appears to be no particular bias between laboratories.

Overall, the NIST SRM 612 glass contains most elements at concentrations of about 38± 12 µg $g^{-1}$, lower than the nominal 50 µg $g^{-1}$ suggested by NIST. NIST SRM 610 contains most elements at about 400± 100 µg $g^{-1}$, again lower than the nominal 500 µg $g^{-1}$ suggested by NIST. Studies which have assumed the NIST nominal concentrations may suffer from up to 25% bias.

Whilst a large amount of data has been published for NIST SRM 612, less is available for NIST SRM 610. This contribution, therefore, represents a substantial increase in the amount of analytical data available for NIST SRM 610 as well as adding valuable data towards the fuller characterisation of NIST SRM 612. The summary tables provide averages which make these reference materials more useful to the micro-analytical community. We will endeavour to maintain and update these compilations and would be grateful for information concerning sources of published data we have overlooked.

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