



# *Sheetlines*

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“The Reichsamt für Landesaufnahme and  
the Ordnance Survey (part 2)”

*J L Cruickshank*

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The Charles Close Society was founded in 1980 to bring together all those with an interest in the maps and history of the Ordnance Survey of Great Britain and its counterparts in the island of Ireland. The Society takes its name from Colonel Sir Charles Arden-Close, OS Director General from 1911 to 1922, and initiator of many of the maps now sought after by collectors.

The Society publishes a wide range of books and booklets on historic OS map series and its journal, *Sheetlines*, is recognised internationally for its specialist articles on Ordnance Survey-related topics.

*The Reichsamt für Landesaufnahme and the Ordnance Survey;  
a comparison of two mapping organisations between 1919 and the  
Second World War (part II)*

*J L Cruickshank*

In the first of this pair of articles I gave a narrative of the development of the *Reichsamt für Landesaufnahme*. In this concluding article I shall compare the *Reichsamt* with the Ordnance Survey in a number of key areas, concentrating on those that affected their performance in the Second World War.

***Photogrammetry***

It is well known that German skills and experience in both terrestrial and aerial photogrammetry remained far ahead of those in Britain. Indeed, although the *Reichsamt* had used aerial survey to produce 1:5000 mapping of the lower Oder in the 1920s, and Berlin had been mapped at 1:4000 from the air in 1928, the British Geographical Section, General Staff (GSGS) had to develop aerial survey techniques with improvised equipment during the Second World War, and it was not until the 1950s that the Ordnance Survey tentatively adopted aerial survey for large scale urban mapping.<sup>1</sup> In contrast, the *Reichsamt* had from the outset an active photogrammetry group. During the 1920s and 1930s the *Mitteilungen* regularly printed articles on aerial survey and photogrammetry, and featured detailed reports of photogrammetry conference presentations from other countries. Just as the Swiss firm *H Wild* of Heerbrugg worked closely with the Swiss Federal Survey, the *Reichsamt* (and other German surveying organisations) worked closely with *Carl Zeiss* of Jena who continued to develop improved optical surveying and plotting equipment. From the 1920s the German national airline, *Lufthansa*, provided a commercial aerial photography service. Franz Novatsky, the head of the *Photogrammetrische Abteilung* of the *Reichsamt*, developed and published methods for establishing triangulation networks from aerial photography.<sup>2</sup> Aerial survey expertise and equipment were immediately available for military needs when war broke out.

Despite this technological lead, it may not have been used to best advantage. During the early part of the war the *Luftwaffe* obtained extensive aerial photo coverage of Britain (and elsewhere) which has subsequently been used for many civilian purposes. Nevertheless, as in Britain, there were competing claims on the available aerial photography, and difficulties for

<sup>1</sup> Dahl, 'Herstellung der topographischen Grundkarte 1:5,000 von der unteren Oder unter Verwendung von Luftbildern', *MdRfL*, **3** (1927/28), 37-40. K Lips, 'Die Luftbildaufnahme von Berlin', *MdRfL*, **4** (1928/29), 185-191. F Nowatzky, 'Die Herstellung der Topographischen Grundkarte des Deutschen Reiches im Maßstabe 1:5,000 durch Luftbildmessung', *MdRfL* **12** (1936), 197-206. P Chasseaud, 'Mapping for D-Day: The Allied Landings in Normandy, 6 June 1944', *Cartographic Journal*, **38** (2001), 177-189, esp. pp 179-180. W A Seymour (ed), *A History of the Ordnance Survey*, Folkestone: Dawson, 1980, 234-235 & 302-304. T Owen and E Pilbeam, *Ordnance Survey, Map Makers to Britain since 1791*, Southampton, 1991, 105 & 131. P Collier, 'Photogrammetry in the Ordnance Survey from Close to Macleod', *Sheetlines* **64** (2002), 15-18. For further aspects of the OS attitude to aerial survey see also C Board, 'Air Photo Mosaics: a Short-term Solution to Topographic Map Revision in Great Britain 1944-51', *Sheetlines* **71**, 24-35. GSGS did have some experience during the inter-war period: the 1934 two-inch map of *Malta and Gozo* (GSGS 3859) was plotted from 1927 air photography. See also Y Hodson, 'MacLeod, MI4, and the Directorate of Military Survey 1919-1943', *Cartographic Journal*, **38** (2001), 155-175.

<sup>2</sup> F Nowatsky, 'Bildtriangulation zur Bestimmung von Paßpunkten', *MdRfL*, **16** (1940), 47-68.

mapping organisations in getting the images they needed. Making images available to external mapping organisations was not seen by *Luftwaffe* intelligence officers as a priority. The *Luftwaffe* had its own mapping organisation that was, to an important extent, in competition with both the *Reichsamt* and the Army's *Kriegskarten und Vermessungswesen*. The difficult question of what payment should be made for the reproduction and use of Air Ministry copyright images had also to be resolved. Only in June 1943 was a decree made that aerial photography could be requisitioned by the *Reichsamt* and that Air Ministry images could be used (subject to restrictions) without payment of copyright fees.<sup>3</sup>

Ordnance Survey has never adopted terrestrial photogrammetry. The *Reichsamt* itself, being a North-German surveying organisation, also had little experience.<sup>4</sup> The techniques had however largely been developed by Swiss, Bavarians and Austrians for Alpine mapping, and the *Reichsamt* had ready access to this expertise.<sup>5</sup> Between the wars the *Deutscher und Österreichischer Alpenverein* (German and Austrian Alpine Club), in particular, had produced a number of photogrammetrically surveyed 1:25,000 maps of the eastern Alps. During the 1930s the *Alpenvereinskartographie* was under the general direction of Prof. Dr Richard Finsterwalder, then of the *Technische Hochschule*, Hannover.<sup>6</sup> In 1939 Finsterwalder was nominated to membership of the *Forschungsbeirat für Vermessungstechnik und Kartographie*, a research committee under the chairmanship of the President of the *Reichsamt* to co-ordinate all the cartographic research bodies in Germany. He also contributed articles on alpine and German colonial surveying, and on the mountain-research programme of the *Alpenverein*, to the *Mitteilung* of the *Reichsamt*.<sup>7</sup> The close links at this time between the German government and what in 1938 became simply the *Deutsche Alpenverein*, combined with the pan-Germanist philosophy of the organisation, eventually led it to be proscribed by the Allies in 1945.<sup>8</sup> The *Kartographisches, früher Militärgeographisches Institut* in Vienna (which from 1938 became *HVMA XIV*) had also been an early pioneer of

<sup>3</sup> 'Beschaffung von Luftbildmaterial für den Vermessungsdienst. Runderlaß der Reichsminister des Innern von 1 Juni 1943 – VIa8209/43-6853 (Luftbildbeschaffungserlaß)', *MdRfL*, **19** (1943), 142-148. This decree had to be made in conjunction with the *Reichsminister der Luftfahrt und Oberbefehlshaber der Luftwaffe* (Herman Goering).

<sup>4</sup> Most of Prussia is very flat.

<sup>5</sup> *Das Reichsamt für Landesaufnahme und seine Kartenwerke*, Berlin, 1931, 22 and *Tafel 5*.

<sup>6</sup> Prof. Dr R Finsterwalder is, for example, credited with the 'Gesamtleitung' of making the map 'Südblatt (Hoch Stubai)' of the two-sheet *Karte der Stubaier Alpen* (Hauptausschuß des Deutschen und Oesterreichischen Alpenvereins, 1937). He continued to work on the *Alpenverein* maps after the war until his death in 1963, being credited for the stereoplotting of the *Ostblatt* of the *Wetterstein- und Mieminger Gebirge* map (1960). The 100th anniversary of his birth in 1999 was celebrated with a *Festschrift* on High Mountain and Glacier Research: K Brunner & W M Welsch (eds), *Hochgebirgs- und Gletscherforschung Zum 100 Geburtstag von Richard Finsterwalder*, Schriftenreihe des Studiengangs Vermessungswesen der Universität der Bundeswehr München, Heft 62, Neubiberg, 1999. Richard Finsterwalder should not be confused with Prof. Dr Sebastian Finsterwalder (1862 - ), of Munich, an earlier pioneer of photogrammetry who surveyed the Vernagt Glacier in Tyrol in 1888-89, was still publishing in the 1930s, and whose 80th birthday was celebrated in *MdRfL*, nor with Prof. Dr Rüdiger Finsterwalder, also of Munich, who subsequently supervised the *Alpenvereinskartographie* from 1966 to 1997.

<sup>7</sup> 'Eröffnungstagung und 1. Fachsitzung des Forschungsbeirats für Vermessungstechnik und Kartographie', *MdRfL*, **16** (1940), 93-109. R Finsterwalder, 'Grundsätzliches zum künftigen deutschen Kolonialmessungswesen', *MdRfL*, **16** (1940), 258-276. R Finsterwalder & H Gänger, 'Die trigonometrische Höhenmessung im Gebirge. Bericht über eine genaue Höhentriangulation in den Chiemgauer Alpen', *MdRfL*, **17** (1941), 3-41. R Finsterwalder, 'Die Kurse für Hochgebirgsforschung 1941 und 1942', *MdRfL*, **19** (1943), 50-56.

<sup>8</sup> The Austrian *Alpenverein* was to be re-founded in 1947; the German *Alpenverein* was not re-founded until 1950. Notwithstanding very close co-operation they remain separate organisations to this day. For a recent account of the history of the *Alpenverein* maps see: K Brunner, 'Die Kartographie im Deutschen Alpenverein', *Kartographische Nachrichten*, **51** (2001), 17-22. This includes references to several earlier accounts, but skips silently over the wartime period.

terrestrial photogrammetry and, despite having been stripped of its equipment and much of its personnel at the break-up of the Danubian Monarchy, had re-established its skills by surveying and plotting the early sheets of the new Austrian 1:25,000 survey. These were all of Alpine areas, principally in Salzburg and East Tyrol.<sup>9</sup> Nevertheless, despite the clear German advantage in this technology, it proved in the event to be of little value in fighting the Second World War, in which active fighting did not reach the high alpine lands.<sup>10</sup>

### *Printing*

Ian Mumford based his doctoral thesis on the premise that the history of lithography as used for printing maps had not been written. He proved the point, but despite the breadth of his thesis he left a number of twentieth-century topics untouched, including the development of offset lithography. He did discuss the very detailed published descriptions of the printing techniques of the *Reichsamt*, although his purpose was principally to use them to illuminate what nineteenth century practice had been, particularly with regard to lithographic engraving. A point he left unstated was that *Reichsamt* practice in the 1940s preserved techniques that had been abandoned (if they had ever been adopted) by other organisations, including the Ordnance Survey.<sup>11</sup>

There is as yet no published overview of the evolution of the Ordnance Survey's reproduction and printing techniques during the twentieth century.<sup>12</sup> Descriptions of particular series include discussions of the form of their master reproduction material, but the actual processes used to print the maps are seldom identified. Unlike most continental mapping organisations the Ordnance Survey had originally made little use of lithographic stones. In the nineteenth century it had not used stones for the master record of any series, but had generally relied on engraved copper plates produced either directly by engraving, or (increasingly) by electrotyping of an older engraved plate. The exception was that most large scale plans were lithographically printed from zinc plates photographically generated from drawn originals. Printing from stone had been reserved for the production of derived sheets intended solely for military purposes. With the preparation of the New Series colour-printed map at the turn of the century the OS did begin to print civilian maps from stone, but the master document remained the engraved plate. Although the second edition (revised 1901) of *Methods and Processes Adopted for Production of the Maps of the Ordnance Survey* does mention transfers to stone and printing from stone, especially for colour printing, these

<sup>9</sup> Joseph Mühlberger, 'Die Entwicklung der österreichischen Staats-Kartographie', *MdRfL*, 5 (1929-30), 193-213. *Entwicklung des Kartographischen Institutes und der staatlichen Kartenherstellung nach dem Umsturz*, Vienna: Kartographisches, früher Militärgeographisches Institut, October 1934. A very compressed account in English is given by Ingrid Kretschmer, 'The Mapping of Austria in the Twentieth Century', *Imago Mundi*, 43 (1991), 9-20.

<sup>10</sup> Terrestrial photogrammetry had been used by the *Militärgeographisches Institut* to map much of the Balkan peninsula during the First World War: see Mühlberger, *op cit.* Whether this coverage was extended during the Second World War I do not know. The technique was used to survey some enemy fortifications early in the Second World War. Assaults on these fortifications proved unnecessary and the surveys were not used in action. See Franz Ackerl, 'Verfahren zur Vermessung von Befestigungen aus großen Entfernungen', *Fachdienstliche Mitteilungen des Obersten Fachforgesetzten des Militärgeographischen Dienstes*, 5, (1972), 35-53.

<sup>11</sup> Ian Mumford, *Milestones in Lithographed Cartography from 1800*, unpublished PhD thesis, Reading University, 1999, 77 *et seq.* An equivalent work covering offset-lithographic map production is badly needed.

<sup>12</sup> This paragraph is based on accounts in the following works: Tim Nicholson, *The Birth of the Modern Ordnance Survey Small-scale Map*, Charles Close Society, 2002, 1-3 and 18-19; Sir H James, rev. D A Johnson, *Account of the Methods and Processes Adopted for Production of the Maps of the Ordnance Survey*, London, 1902, esp. 170, 173-4, and 185-188; and A Y Hodson, *Popular Maps*, Charles Close Society, 1999, which includes, as chapter II, a particularly valuable discussion.

appear as brief after-thoughts following long descriptions of zincography. Thereafter, however, transfers to stone became progressively more important as colour printed maps came to dominate the Ordnance Survey's output. For the Popular Edition one-inch map of England and Wales the immediate master documents were lithographic stones, although the distant origin of the map remained the nineteenth century engraved plates. During the early 1920s engraving was abandoned at the Ordnance Survey and all but one of the engravers were sacked. The master documents of the Scottish Popular one-inch map were drawings on paper. From these, photographic glass negatives were prepared which constituted the master material. Metal printing plates were in turn prepared photographically. The complexity of these different processes and of their evolution, however, obscures an underlying simplicity. By 1932, if not earlier, printing directly from stone had become exceptional at Ordnance Survey.<sup>13</sup> Rotary offset-lithographic printing from zinc plates was the normal production process; indeed it was so normal as to be unstated. During the Second World War the Ordnance Survey's Southampton headquarters was to become progressively less important as a printing facility. Its pre-eminent role became the production of enamelled-zinc offset-printing plates for use elsewhere in Britain or the world.

The reproduction material and printing processes were starkly different in Berlin. The *Preußische Landesaufnahme*, which had originally drawn its maps on stone, had for some decades before the First World War been transferring existing reproduction material from stone to copper plates by photo-etching, and had still been preparing plates for new sheets by hand engraving of copper. The justification for this was that copper plates were both easier to revise and, when used directly for printing, gave finer line quality.<sup>14</sup> Notwithstanding these principles, few direct impressions from the copper (or master stones) were made. The vast majority of the maps printed, whatever form the master material took, were in fact produced from lithographic transfers to machine stones. Nevertheless all the small-scale series were cast on very small sheet-lines. This permitted copper plates to be used for printing multi-coloured maps, but meant that huge numbers of individual sheets had to be maintained.<sup>15</sup> During the 1920s the *Reichsamt* continued these policies, in part because there were few newly surveyed or revised maps to be engraved, but also perhaps because there was little money to buy new equipment. In 1925 the *Reichsamt*'s stone and plate store contained about 12,000 lithographic stones, 5000 copper plates and 16,000 aluminium plates. Of these, the copper plates and about 3800 of the stones constituted master copies.<sup>16</sup> The aluminium plates were for offset lithographic printing, but many of these may have been prepared for military purposes during 1914-18. The *Reichsamt* never used zinc printing plates, although zinc had been used in Field Printing Units during the war. During the inter-war period the use of offset

<sup>13</sup> R Hellyer and R Oliver, *Military Maps; The One-inch Series of Great Britain and Ireland*, Charles Close Society, 2004, 14.

<sup>14</sup> Kleffner, 'Der Kupferstich und die Karte 1:100,000', *MdRfL*, 2 (1926-27), 17-25. These arguments are almost exactly those given in support of the engraved Ordnance Survey maps before their demise.

<sup>15</sup> The size of sheets varied with latitude, but a 1:100,000 sheet might measure 30 × 28 cm between the neat lines, or less. This is less than two-thirds of the printed area of an OS New Series one-inch sheet. Sheet sizes for the 1:300,000 series, which was engraved on stones, were larger (N55 Stralsund measures 44 × 37 cm), but were still much smaller than inter-war British quarter-inch sheets.

<sup>16</sup> The master copies for the series at 1:25,000, at 1:300,000, and at 1:800,000 were stones. The 1:100,000 and 1:200,000 maps were engraved on copper. The small number of 1:50,000 maps were partly on stones and partly had been transferred to copper plates by photo-galvanography. For reasons of cheapness the new 1:5000 map was intended to be drawn, before being transferred to aluminium plates by photoalgraphy. 'Das Reichsamt für Landesaufnahme', *MdRfL*, 1/1 (1925), 3-19, esp. 13-15.

printing was limited to production of the 1:25,000 sheets, for which a coarser line quality was felt unimportant.<sup>17</sup> From about 1930 the *Reichsamt* started to experiment with a variety of new ways of generating master reproduction material for the 1:25,000 and 1:50,000 maps, so avoiding the cost of hand-engraving copper plates. Nevertheless most production printing continued to be done on flat-bed presses (*Steindruckschnellpressen*) using transfers to machine stones.<sup>18</sup>

Although offset-lithographic printing had been invented during the nineteenth century, its practical development began at the beginning of the twentieth century. Koeman however commented that most of the major European map producers were slow to adopt the technique. He suggested that despite the opportunity to print larger numbers of maps in shorter times using offset printing from zinc plates, they were reluctant to abandon the slower printing from stone because of the enormous capital represented by their existing stocks of stones.<sup>19</sup> While his generalisation has some truth, the reality was a good deal more complex. In 1910 the *Militärgeographisches Institut* in Vienna (which for its principal map-series had used copper plates produced by heliogravure from drawn originals) installed the first rotary offset-litho map-printing press in continental Europe. By the end of the First World War it had installed eleven more. The break-up of the Danubian Monarchy at the end of the war led to the dismantling of this facility, but offset printing continued.<sup>20</sup> As noted above, single-colour offset printing was also used during and after the 1914-18 war in Germany, but during the post-war period it seems to have lost ground because of coarser line quality, and also perhaps because edition sizes were so much smaller.

Subsequent technical development led to the introduction of two-colour offset-litho presses. In Britain these were widely available by 1929, in which year a four-colour machine was exhibited.<sup>21</sup> Although described in the printing handbook produced by the Austrian survey in 1930,<sup>22</sup> two-colour machines were first mentioned at the *Reichsamt* in 1938, when they were described as a new innovation. The set-up time of these machines was apparently substantially longer than for single-colour presses. Their use was therefore stated only to be viable for editions of 10,000 copies or more ‘that in normal times do not come often’.<sup>23</sup> Despite their introduction, flat-bed printing remained the usual means of production. In 1937 there were only thirteen offset-printers at the *Reichsamt* as against forty stone-printers (plus four full-time stone-polishers amongst members of other lithographic trades).<sup>24</sup> Even in 1941,

<sup>17</sup> *Das Reichsamt für Landesaufnahme und seine Kartenwerke*, Berlin, 1931, 47-49 and *Tafel 12*.

<sup>18</sup> Otto H Krause, *Neue Wege der Kartenherstellung im Reichsamt für Landesaufnahme*, Sonderheft 9 zu den *MdRfL.*, second edition., Berlin, 1936. H. Bosse, ‘Der Kartendruck’, *MdRfL*, **17** (1941), 113-153.

<sup>19</sup> C Koeman, ‘The Application of Photography to Map Printing and the Transition to Offset Lithography’, (in) D Woodward, *Five Centuries of Map Printing*, Chicago, 1975, 137-155.

<sup>20</sup> In 1929 it was stated that during the 1914-1918 war, by the uninterrupted work of twenty-one *Schnellpressen*, including twelve offset presses (and so by implication nine flat-bed presses), 65 million map sheets of an average size of 50 × 70 cm were printed in Vienna: Mühlberger, *op cit.*, 208. Kretschmer (*op cit.*, 13) quotes the same output figures, but mentions only eight rotary offset presses.

<sup>21</sup> C.H., ‘Offset Printing Machines, Flat-bed and Rotary’, (in) *Printing in the Twentieth Century; a Survey*, London: The Times Publishing Company, 1930, 198-200.

<sup>22</sup> The handbook for reproduction technicians (*Reproduktionstechniker*) of the Austrian Survey provides detailed instructions both about single colour offset printing and about two-colour offset lithography presses: Rudolf Sauer, *Reproductions-technisches Handbuch*, Vienna: Kartographisches, früher Militärgeographisches Institut, 1930, especially 205-208.

<sup>23</sup> ‘die in normalen Zeiten nicht häufig vorkommen’: H Ermel, ‘Moderne Arbeitsverfahren bei der Herstellung amtlichen Karten’, *MdRfL*, **14** (1938), 354-358, see especially 357-358.

<sup>24</sup> ‘Die Reichsamt für Landesaufnahme auf der Ausstellung “Gebt mir vier Jahre Zeit”’, *MdRfL*, **13** (1937), 227.

two years into the Second World War, offset printing only occupied just over three pages of text at the end of a forty-page article on printing at the *Reichsamtsamt*. The continued use into the distant future of the old-fashioned *Steindruckschnellpresse* alongside offset-machines was assumed.<sup>25</sup>

### ***Organisation and Remit***

There were very striking differences between the survey organisations of the two countries in the clarity of their remits and the stability of their organisations. In Britain, the Ordnance Survey's business was to map Britain alone. In peacetime, colonial and overseas mapping, and maps for military purposes, were not the Ordnance Survey's business. In wartime, the Ordnance Survey's role was different, but in the run up to the Second World War almost all its senior staff had experience of its 1914-18 wartime role. In fact, because British military mapping during the First World War had been developed from small beginnings by a group of very junior officers, it was this same group that had become the senior officers of both Ordnance Survey and GSGS during the 1920s and 1930s. In 1940 most had only recently retired from military service (at low military retirement ages). Many were still very much active. The organisations still reflected their ideas and experiences. In truth, despite retrenchment, organisational change in Britain had been modest. The structures of both Ordnance Survey and GSGS were recognisably similar in 1918-19 and 1939-40. Organisational change became an issue during the Second World War, but even then the changes were evolutionary rather than revolutionary.<sup>26</sup>

In contrast, the *Reichsamtsamt* was an entirely new organisation created in 1919-21. As a civilian organisation, it was fundamentally different to its military predecessor. It had to establish its new role from scratch. Furthermore from 1933 onwards the *Reichsamtsamt* was subject to continual change in its organisation. The German Army General Staff too was a body that had had to be rebuilt from almost nothing.<sup>27</sup> As war approached, the *Reichsamtsamt's* roles in wartime had to be defined, as had to be the role of the new military mapping body. Most of the leaders of German mapping organisations during the First World War had been older and more senior than those on British side. Not only had most retired at the end of that war, but their obituary notices were starting to appear in the *Mitteilungen*.<sup>28</sup> Thus not only was their experience less relevant, much of it was no longer available. One result of the lack

<sup>25</sup> H Bosse, 'Der Kartendruck', *MdRfL*, **17** (1941), 113-153, but specifically 148-151. There are two paragraphs about the preparation of offset printing plates, one on p 137 and one on pp 140-141.

<sup>26</sup> For the inter-relationships of Ordnance Survey and GSGS see Y Hodson, 'MacLeod, MI4, and the Directorate of Military Survey, 1916-1943', *Cartographic Journal*, **38** (2001), 155-175.

<sup>27</sup> It should be appreciated that not only did the Army (*Heer*), *Luftwaffe* and Navy (*Kriegsmarine*) all create their own General Staffs, Hitler also established a further General Staff (*Oberkommando der Wehrmacht*) to impose his directives over all of them. It should also be appreciated that the command relationships between these different staffs differed between different theatres of war.

<sup>28</sup> Siegfried Boelke (*Kriegsvermessungschef* from July 1915) died, aged only 54, in 1930 (*MdRfL*, **6** (1930/31), 1). Max Eckert (*Leiter* of *Vermessungsabteilung* 19, A.O.K III) died in 1938 (obituary in *MdRfL*, **15** (1939), 5-11). General von Bertrab (*Chef* of the *Preußische Landesaufnahme* 1911-1914 & 1917-1918) died in 1940 (*MdRfL*, **16** (1940), 46). Generalleutnant Georg Weidner (first President of the *Reichsamtsamt*) died in office in 1924. Richard von Müller (second President) died in 1942 (*MdRfL*, **18** (1942), 187). Both Boelke and Eckert had published accounts of German military mapping during World War I: see Peter Chasseaud, 'German Maps and Surveys on the Western Front, 1914-1918', *The Cartographic Journal*, **38** (2001), 119-134. Further biographical details are given in Oscar Albrecht, *Das Kriegsvermessungswesen während des Weltkrieges 1914-18*, München: Deutsche Geodätische Kommission, Reihe E, **8**, 1969, Anhang B.

of clarity about the *Reichsamt*'s role was that at the beginning of the war it was subject to a multitude of internal and external demands that could not simultaneously be satisfied.

The size of Britain did not change (other than by coastal erosion and deposition), but in the 1920s Irish Home Rule did substantially reduce the area to be mapped by Ordnance Survey. There were very few changes in the administrative divisions of Britain, and while the boundaries of some large towns were extended during the inter-war period, the mapping of these changes was regarded as a minor issue. Alterations were readily incorporated on the successive new editions of the small-scale maps, and were merely another element in the backlog of change to be incorporated on the large-scale plans. There was no political imperative to map such changes with any urgency. In Germany, however, the area the *Reichsamt* was required to map expanded rapidly, particularly from 1938 onwards. There were enormous political pressures to map new boundaries and new place-names, especially in the territories newly incorporated into the *Reich*, because mapping was seen as an important assertion of sovereignty. The publication of maps with German place-names was similarly a symbol (and an assertion) of German identities for the places.<sup>29</sup> The magnitude of the task created by this sudden (and unplanned-for) expansion in the area to be mapped by the *Reichsamt* had no parallel for the Ordnance Survey.<sup>30</sup>

When war broke out the Ordnance Survey was able to solve the problem of keeping up-to-date mapping secret very simply; it just stopped selling maps to the public. Most of the large-scale maps were in any case well out of date. Some limited piecemeal large-scale revision (the ARP revision) was plotted on six-inch maps, but this was targeted at wartime administrative needs and the sheets were distributed on a 'Restricted' basis.<sup>31</sup> Military and other strategically important installations had in any case been omitted from maps for public sale since the nineteenth century.<sup>32</sup> In Germany a much more cumbersome process was adopted. Maps remained on sale, but in February 1940 an order was made that no published map should show any revision of economically or militarily important information more recent than 1933. In particular, new roads and railways could not be shown. This had the effect that almost any map that had recently been revised now had to be un-revised before it could be made publicly available once more. This created an immense but fundamentally unproductive task that was probably pointless, and no doubt dispiriting, at a time when other tasks might have taken priority.<sup>33</sup>

<sup>29</sup> Similar considerations have led to the continuing availability (see Part I) of German mapping of the parts of the Reich lost sixty years ago.

<sup>30</sup> Once preparations for an attack on the USSR had to be made, the area needing to be mapped became vast; in essence all Europe west of the Urals. The *Mitteilungen* are however silent about how this problem was dealt with and which organisation did it. Some mapping was derived from Russian originals, but accurate Russian-made topographic mapping of Russia has always been secret. Maps that were copied for the German Army attack on Moscow proved to contain deliberate misinformation about the road system, and its relationship to gorges and swamps: see K Brunner, 'Geheimhaltung und Verfälschung von Karten aus militärischen und politischen Gründen', (in) D Unverhau (ed), *Kartenverfälschung als Folge übergroßer Geheimhaltung? Eine Annäherung an das Thema Einflußnahme der Staatssicherheit auf das Kartenwesen der DDR*, Archiv zur DDR-Staatssicherheit, Band 5, Münster: Lit Verlag, 2002, 161-175; and see Kyrill D Kalimow, *Sowjetmarschälle haben das Wort*, Hamburg, 1950, 161-5.

<sup>31</sup> T Owen and E Pilbeam, *Ordnance Survey, Map Makers to Britain since 1791*, Southampton, 1991, 115.

<sup>32</sup> Pre-war policy and practice in Britain had in fact been highly inconsistent. See A Y Hodson, *Popular Maps*, Charles Close Society, 1999, 157-168.

<sup>33</sup> 'Verordnung über die Veröffentlichung kartographischer Darstellung vom 6. Februar 1940', and 'Erste Durchführungsbestimmungen zur Verordnung über die Veröffentlichung kartographischer Darstellung vom 6. Februar 1940', *MdRfL*, 16 (1940), 42-45. See also the Annual Report to 31. 3. 1941, *MdRfL*, 17 (1941), 245.

That this was felt necessary reflected the German propaganda aim of maintaining an illusion of peace and normality amongst the civilian population of Germany. To those in Germany, the sudden conquests of France, the Low Countries, Denmark and Norway in 1940 appeared to happen without noticeable cost, just as had been the case when Czechoslovakia and Poland were occupied in the previous two years. Peacetime activities were required to continue, and to a very great extent the populace were not informed of the magnitude of the struggle that was under way. A corollary of this was that Germany's economy was not run on a war basis until surprisingly late in the war, and thus industrial output in Germany did not peak until 1944. In Britain, on the other hand, the events of the summer of 1940 made it clear to all that 'there was a war on', and that many peacetime activities had to be shelved in favour of 'the war effort'. This requirement to focus all activity on the war was universally accepted; the end of production of maps for civilian purposes was just one minor aspect of this.<sup>34</sup> This unity of purpose (remembered fondly by those who experienced it) was an important element in the eventual Allied victory.

Even after the tide of the war turned, projects that were essentially civil continued to occupy the *Reichsamt* and its subsidiary mapping bodies. From the middle of 1941, the rising death toll on the Russian Front became obvious from the honour rolls printed in every issue of the *Mitteilungen* (and most other periodicals). The defeats of the winter of 1941-2 in Russia were followed by further defeats on all fronts and, in the winter of 1942-3, by the disaster of the siege and fall of Stalingrad. Yet as late as 1943 a magnificent tourist map, the 1:25,000 *Granatspitzkarte des Deutschen Alpenvereins*, was published by *HVMA XIV* in Vienna. This was a large-format mountain map in five colours, showing way-marked paths and *Alpenverein* huts, and was derived from six pre-war sheets of the new Austrian 1:25,000 survey.<sup>35</sup> The Granatspitze is in central Austria and was far from any immediately likely scene of military operations. In Britain there had been no new printings of existing tourist maps since the beginning of the war, and any proposal to prepare a new tourist map at this time would have been inconceivable. Even in August 1944 (after the D-day landings), a set of different multi-colour trial-printings of part of one Bavarian 1:25,000 sheet (6234 Pottenstein, in Franconia) were published in the *Mitteilungen*, along with many photographs of the area. The accompanying text gives an account of attempts to perfect the precise representation of relief in this picturesque limestone *Karst* area using hill-shading and differing contour intervals; interesting work, perhaps, but in the context of the war a complete waste of time and resources.<sup>36</sup>

### ***Small-scale mapping***

The *Reichsamt* and Ordnance Survey had given very different priority to the small-scale mapping of their countries. Hindsight often shows peacetime generals to have made preparations to fight the previous war again, rather than the next one. While examples of such preparations contributing to the early reverses of France and Britain in the Second World War have been widely discussed, equivalent failures on the German side have less

<sup>34</sup> In fact, during the later part of the war, copies of the military maps of Britain (many of which included much more up-to-date revision than the pre-war civilian issues) were released for public sale. See R Hellyer and R Oliver, *Military Maps; the One-inch Series of Great Britain and Ireland*, Charles Close Society, 2004.

<sup>35</sup> The fourth edition of this map (*Granatspitzgruppe*, Alpenvereinskarte 39, 1988) covers a smaller area and (at least in my copy) has a much coarser line quality. It is also very coy about the publisher of the 1943 edition.

<sup>36</sup> H Schaefer & H Schmitthenner, 'Topographisch-Morphologische Kartenproben 1:25,000, Kartenprobe 22 "Karst"', *MdRfL*, 20 (1944), 104-117 (plus ten map extracts and five loose sheets of photographs).

often been noted. However there was a profound difference in the nature of warfare between the First and Second World Wars, and thus in the mapping required. In the First World War, position (trench) warfare developed on almost all fronts. On the Western Front, on the Alpine Front, in Macedonia, and at Gallipoli it predominated. For such warfare large-scale mapping based on accurate and precise trigonometrical control had become crucial.



*During the 1920s, in order to take advantage of the growing demand for motoring maps, the Reichsamt issued some of its 1:300,000 sheets with additional road information as the Deutsche Motorfahrer Karte. This series was re-launched in the 1930s as the Reichs-Auto-Karte.*

In the light of this, throughout the inter-war period the *Reichsamt* devoted much of its very limited resources to large-scale surveys of its own territory and the improvements to its triangulation networks that they required. As a consequence, small-scale mapping was to a great extent neglected. The obsolescent 1:100,000 map with hachures was maintained and gridded; its intended replacement, the 1:50,000 map, did not progress beyond a few experimental sheets. The new but incomplete 1:200,000 map with contours was abandoned

for much of the period, while the older hachured 1:300,000 was maintained. On these maps the black plate carried both the grid and most of the topographical information. Any revision involved difficult changes to this very crowded black outline plate. Particularly for the 1:300,000, for which the master reproduction material was engraved stones, this could be a very cumbersome process indeed.<sup>37</sup>

Yet the Second World War turned out to be a war of movement, often fought over substantial distances. Motor transport, armoured vehicles, aircraft and artillery all moved faster, and acted over longer ranges, than twenty-five years earlier. Large-scale mapping turned out to be less important than good quality small-scale mapping extending over wide areas. The ability to produce provisional mapping that could be revised rapidly and repeatedly in the light of new information or better surveys proved immensely important, particularly for operations outside home territory.

Between the wars the Ordnance Survey had neglected large scale mapping in favour of developing its small-scale series. The 1:63,360 Popular Editions of England & Wales and of Scotland had not only been completed, but were in process of replacement by further new series. Two successive 1:253,440 series had been completed for the whole of Britain. The styles of these multi-coloured maps, and their reproduction methods, had been developed in an environment of forced economy, speed, and efficiency.<sup>38</sup> The reproduction material for relief portrayal was, in particular, fully separated from that of other categories of information, and all maps at 1:10,560 and smaller scales were contoured throughout.<sup>39</sup> Despite its brief return on the Fifth Relief Edition of the one-inch map, hachuring had finally been abandoned. Other categories of information appeared only on one or other coloured plate. Sheet sizes were large. Legibility was good, even in poor light. These were exactly the sort of maps that turned out to be required for the Second World War. The civilian maps of the Ordnance Survey were not uniformly gridded, but a system had been developed by GSGS whereby a grid (and other military information) was overprinted in purple on otherwise civilian maps.<sup>40</sup> Despite the practical disadvantage of requiring an extra pass through the printing press, and the more theoretical disadvantages of the grid being only indirectly (and perhaps approximately) related to the base map, the system proved legible, flexible and adaptable.<sup>41</sup> Revision or replacement of the base map did not require modification of the grid plate. A coloured overprint bearing a grid (and for maps at junctions of grid zones, different coloured overprints) became characteristic of much Allied Second World War mapping. Simply by

<sup>37</sup> For an experimental printing of a 1:300,000 sheet (L52 Kassell) with the main-road network only on the red plate see H J v. Loeschbrand-Horn, 'Die Modernisierung alter Kartenwerke', *MdRfL*, **13** (1937), 262-264, Anlage 2. Like the Ordnance Survey, the *Reichsamt* was troubled by the rapidly changing quality of the road network and the implications of this for the representation of roads on its maps. One particular difficulty was that a new symbol had to be devised for Hitler's new *Autobahnen*. Another was that an inelegant convention had previously been introduced in which the width of the red 'infill' indicated the importance of the road for through traffic. For trunk roads (*Vernverkehrsstraßen*) it was wider than the pair of black lines it infilled. For the OS response to such problems see A Y Hodson, *Popular Maps*, 1999, chapter VII.

<sup>38</sup> Director-General H StJ L Winterbotham commented of the Ordnance Survey that 'The drawing room is neatly papered with good small-scale maps, the rest of the house is beginning to show dry-rot', (quoted in Owen and Pilbeam, *op cit.*, 105).

<sup>39</sup> Except for the 1:10,560 sheets of the north of Scotland.

<sup>40</sup> For the many complexities concealed by this sentence, see R Hellyer and R Oliver, *Military Maps; the One-inch series of Great Britain and Ireland*, Charles Close Society, 2004.

<sup>41</sup> The Popular Edition one-inch map of England and Wales was constructed on the non-rectangular Cassini projection and also included much local distortion due to the complex history of its reproduction material. Fudging rectangular grids to fit these maps could be immensely time-consuming. Hodson, *op cit.* (1999), 76-77.

replacing the grid overprint with a different one, graticule editions of the same maps for air use were also readily produced.

In comparison, the old-fashioned small-scale mapping of the *Reichsamt* was cumbersome and inflexible. The fine detail of the black plates required good light to be read. The extensions to the *Reich* before war broke out proved difficult to map adequately within the time allowed, while the mapping prepared of areas outside the *Reich* was un-gridded and inadequate for military purposes. The small sizes of the series-sheets proved to be impractical; progressively larger compilation sheets had to be created. The immense extensions to the area to be mapped at small scales, particularly in the east, challenged all the peacetime assumptions of the *Reichsamt*. How those challenges were met in wartime is, however, not revealed in the openly published documents used for this study.

### ***Civil-military interaction***

It would be ridiculous to write an analysis of the interrelationships of the *Reichsamt* with its military and *Luftwaffe* counterparts from the publications available for this study, just as it would be ridiculous to base an account of the interactions of the Ordnance Survey and GSGS purely on published material. Nevertheless some questions and areas for future enquiry do emerge.

That *Kart II.* of the *Reichsamt* produced ungridded maps of Britain and elsewhere for military use suggests (at the very least) poor liaison between the civil and military organisations. Rather than military considerations being able to dictate the specifications of the maps produced, the *Reichsamt* seems to have been allowed to produce the maps it felt able to supply. The establishment of *Kart II.* without trigonometric or compilational personnel seems to have been a minimalist response to an instruction to prepare mapping of other countries. Vollmar, the President of the *Reichsamt*, probably had a perfectly clear idea of military needs. He had been a serving officer until his appointment in 1934, and had previously been the military representative on the *Beirat für Vermessungswesen* and the liaison officer between the *Reichsamt* and the *Reichswehrministerium* (Ministry of Defence). Nevertheless he seems to have seen his role as firstly to defend the *Reichsamt* against efforts to fragment it, and only secondly to provide a service to other agencies. While this was probably entirely normal (and necessary) behaviour for a peacetime head of a civil-service office, it significantly hampered military preparations for war. Vollmar's outranking of the Chief of the military department must however have assisted him in asserting the primacy of the civilian body, and in retaining control of *Kart II.* and its personnel, even when its tasks were military. Rivalry and conflict between the leaders of military and civilian mapping bodies existed in Britain, but it may well have been even greater in Germany.<sup>42</sup> The deliberate creation of overlapping responsibilities (and the separation of chains of responsibility from chains of command) were characteristic of Nazi government; inter-departmental feuding frequently resulted.<sup>43</sup> The effects of this within the German mapping services, and of the shifting balance of power between the services, merit further examination. In 1941 Hemmerich was promoted to Generalleutnant, and by 1943 he was asserting the supremacy of his military mapping body over all the national mapping bodies of

<sup>42</sup> For an account of what happened in Britain see Y Hodson, 'Macleod, MI4, and the Directorate of Military Survey, 1916-1943', *Cartographic Journal*, **38** (2001), 155-175.

<sup>43</sup> For a concise, but penetrating, analysis of this aspect of Hitler's rule see W Carr, *A History of Germany 1815-1945*, revised edition, London: Edward Arnold, 1972, 372.

occupied Europe, including the civilian bodies in Germany. A *Führer*-order of 1942 even apparently authorised him to take command of the *Reichsamt* and all the *Hauptvermessungsabteilungen*, although he never felt able to take that step.<sup>44</sup>

Vollmar may have had further reasons to feel under threat from expansion of the armed forces, and in particular from any war. On the outbreak of war, the benefit of the rapid expansion of the number of apprentice cartographic craftsmen at the *Reichsamt* during the late 1930s was almost entirely gained by the Army. The first batch were only due to return from military service in the autumn of 1940, by which time Poland and France had fallen and the war was very much under way.<sup>45</sup> Traditionally, in both Germany and Austria, service in the military mapping bodies was seen as a peacetime posting for front-line officers and men. On general mobilisation, these would all would return to their units. The trigonometrical and topographical departments would be closed down during hostilities, leaving only the cartographic department to function as a map printing unit in the state capital. This was very much what had happened at the outset of the First World War, both in Berlin and Vienna. The establishment of front-line military surveying units had been a subsequent innovation during that war. There was no previous precedent to indicate what would happen to a civil mapping authority that was largely staffed by retired military officers and men. In the event the *Reichsamt* and all its departments did continue in being during the war, but there is no mention in the *Mitteilungen* of any of its peacetime apprentices returning from the colours. The long lists of deaths in action indicate that many never resumed civilian life, while the postings given also show that the army did not usually use their cartographic skills.

At the beginning of the war Ordnance Survey also lost large numbers of personnel to active service units, although in the absence of universal compulsory military service the loss of recent trainees was only partial. On mobilisation, Ordnance Survey lost seventeen Royal Engineer officers and 500 other ranks, plus a further 180 reservists, territorials and militia. Furthermore, within six months a quarter of the two-and-a-half thousand civil assistants had been called up. However the Ordnance Survey had a larger initial number of staff than the *Reichsamt*, and was also initially able to make good some of its losses by recruiting new staff from civilian printing firms, while women and boys were soon recruited as trainees.<sup>46</sup> In Germany there was no equivalent pool of skilled workers to recruit because of the very specialised lithographic printing techniques used by the *Reichsamt*. Essentially only workers in the private sector cartographic industry had the skills required, and regulations had already

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<sup>44</sup> Existing accounts of the Military and Luftwaffe mapping organisations during this period (all prepared by members of their successor organisations) avoid mentioning the *Reichsamt*; this very silence is significant: Theo. Müller, 'Überblick über das Karten- und Vermessungswesen des deutschen Heeres von 1919 bis 1945', *Fachdienstliche Mitteilungen des Obersten Fachvorgesetzten des Militärgeographischen Dienstes* 5 (1972), 3-33; Jochen Landmann, 'Das Militärische Karten- und Vermessungswesen in Südwestdeutschland; Ein Beitrag zur Geschichte im 20. Jahrhundert', *Militärgeographischer Dienst der Bundeswehr, Schriftenreihe* 30 (1996), 1-104; Winfried Schrödter, 'Luftgeographie, Karten- und Vermessungswesen in der Luftwaffe 1888-2002', draft notes for a history, published on the internet at <http://home.vexilli.net/HisMGLW>. For extracts from Hemmerich's 1943 paper (and a passing mention of his 'difficulties' with the *Reichsamt*) see Max Kneissl, 'Generalleutnant Gerlach Hemmerich, sein Werk und Wirken. Eine Studie zu seinem 90. Geburtstag am 4. Februar 1969', München: Deutsche Geodätische Kommission, Reihe E, 8 (1969), 9-21. Considering the First World War, Peter Chasseaud identified similar conflicts between the *Preussische Landesaufnahme* in Berlin and the *Kriegsvermessungswesen* in the field: P Chasseaud, *An Analysis and Evaluation of British, French and German Military Field Survey and Mapping in the First World War*, unpublished thesis, University of Greenwich, December 2003, 129, 184.

<sup>45</sup> Speech by H J von Loeschebrand to the Deutsche Kartographische Gesellschaft meeting of October 1938, 'Gegenwartsforderungen in der Kartographie', (printed in) *MdRfL*, 14 (1938), 324-329, see especially 328.

<sup>46</sup> Seymour, *op cit.*, chapter 28. Owen & Pilbeam, *op cit.*, pp 113-118.

been made to prevent them being poached by the *Reichsamt*. I have found no sign that the *Reichsamt* felt able to recruit women. The attitude of the Nazi state to women in the workplace was shaped by its early membership. The original core of the party had been a socially very conservative group characterised as small shopkeepers, foremen and supervisors. The woman's role was proclaimed to be '*Kinder, Kirche, Küche*' (children, church and kitchen).<sup>47</sup> Her foremost duty was to bear children and to propagate the master race. It was most certainly not to compete with men for jobs. Nevertheless, despite Nazi dogma, employment and training opportunities for women did eventually increase during the war, as men had to be replaced in the workplace and as breadwinners. It is possible that they were eventually recruited by the *Reichsamt*, but that their employment was not publicised.<sup>48</sup>

### ***Post-war developments***

Finally, the greatest difference between the two mapping authorities was that the Ordnance Survey survived the end of the Second World War. Indeed, despite the destruction of much of its survey archive (and history) in an air raid, the OS might have been said to have had a good war. It had risen to many challenges successfully, and rose to more in the post-war period. It continues to flourish sixty years later.

Like all the institutions of the German *Reich*, the *Reichsamt für Landesaufnahme* ceased to exist following the defeat of 1945. Nevertheless, some continuities can be traced through the meltdown of social and administrative structures that followed the conquest of Germany, its four-power occupation, and its subsequent rebirth as two smaller countries with radically opposed political systems. Following the end of the war part of the *Trigonometrische Abteilung* found itself an operational base at Bamberg in northern Bavaria. After several changes of name, it was relocated in 1950 to Frankfurt-am-Main and renamed once more as the *Institut für Angewandte Geodäsie* (Institute for Applied Geodesy). Erwin Gigas, the former head of the *Trigonometrische Abteilung*, became head of the new organisation. In West Berlin the *Amtliche Anstalt für Kartographie und Kartendruck* was established as a successor to the *Kartographische Abteilung*. From 1954 it was co-ordinated with the *Institut für Angewandte Geodäsie*, and from 1956 was merged with it. In the decentralised federal structure that was created for West Germany the production of all maps of scales larger than 1:200,000 became the responsibility of the separate *Länder*, but the *Institut* retained responsibility for smaller-scale official mapping, geodetic and cartographic research, special projects for federal bodies, and international co-ordination. It also continued to supply unrevised copies of German mapping of the lands lost to Germany at the end of the war. Following the reunification of Germany west of the Oder-Neisse line, it was (in 1997) renamed as the *Bundesamt für Kartographie und Geodäsie*, and as such continues to this day. Nevertheless it is a much diminished organisation in comparison with its predecessor. It has no primary surveying or mapping functions and its output of small-scale derived maps is overshadowed by the much larger output of the private sector.<sup>49</sup> In geodesy its role is

<sup>47</sup> In one of Hitler's speeches, the emancipation of women was condemned as an idea made up only in the Jewish intellect. Speech of 8 September 1934, reprinted in Ute Benz, *Frauen im Nationalsozialismus*, München: Verlag CH Beck, 1993, 42.

<sup>48</sup> The roles of women, and women's work, in the Nazi state are discussed in Ute Benz, *op cit.*, see especially pp 35-36. See also T Mason, 'Women in Germany 1925-1940; Family, Welfare and Work, Part II', *History Workshop Journal* 2 (1976), 5-32.

<sup>49</sup> The current 1:200,000 sheet lines conform rigidly to an old-fashioned grid pattern with tiny sheet sizes. Most sheets are ten years or more out of date.

research, and in this it is subordinate to the *Deutsche Geodätische Kommission*. In all of these roles it has no real British equivalent. Perhaps, however, its weakness reflects a weakness in the *Reichsamt* between the wars. The leading role of the *Reichsamt's* trigonometrical department and the lesser status of its cartographic department were reflected in the structure of the post-war body, especially in the very belated inclusion of the successor to the cartographic department in what had become explicitly a geodetic organisation. The strength of the Ordnance Survey has been that geodesy has always been subservient to the production of maps.

### *Note on Sources*

I have to emphasise that in writing this (exploratory) account of a foreign mapping organisation I have relied on printed public sources rather than archival material. As should be obvious, the weaknesses of this approach are considerable, not only for the period of the war but also for the run-up to it. Nevertheless what is perhaps surprising is how much information entered the public domain, even after the Nazi seizure of power. Answers to many of the questions arising from the present account will however only emerge from archival work, while some of my interpretations of the published material may also require adjustment.

I am also acutely conscious that the German-language literature on the history of cartography is very large, while my access to it has been much more limited than it deserves. The period under examination is still however an uncomfortable one for many Germans, and I have found little recent work on the *Reichsamt* to set alongside the Society's work on the Ordnance Survey.<sup>50</sup> If nevertheless there are significant publications and sources that I have missed, I would be grateful if they could gently be drawn to my attention, if possible with photocopies, or the names of UK libraries holding them.

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<sup>50</sup> Descriptions of the post-war fates of the *Reichsamt's* buildings and reproduction materials have however been published: Wolfgang Weber, '25 Jahre Außenstelle Berlin des Instituts für Angewandte Geodädie (1956-1981)', *Nachrichten aus dem Karten- und Vermessungswesen*, **86** (1981), 9-24; Rolf Böhme, *Der Verbleib der Originale der amtlichen Kartenwerke des Deutschen Reiches*, München: Deutsche Geodätische Kommission, Reihe E, **16** (1978).

<sup>1</sup> Also arsenic, haematite, iron, manganese, mispickel, ochre, wolfram, uranium and zinc.