Part III
Dual Use, Storage and Disposal of Chemical Weapons Today

The Reconstruction of Production and Storage Sites for Chemical Warfare Agents and Weapons from Both World Wars in the Context of Assessing Former Munitions Sites

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Abstract This chapter begins by listing the quantities and sites of chemical agent production during both world wars and outlining the relative importance of these new weapons. Using the example of the production sites of World War II, the setting in which the construction and operation of these factories took place will be described, as well as the structure of the facilities. It will be shown that it was not only Fritz Haber's former colleagues who made important contributions to the research of chemical warfare agents and their production, but that an important role was also played by students of his successor at the Kaiser Wilhelm Institute for Physical Chemistry and Electrochemistry. In order to be employed militarily, chemical warfare agents must be put into grenades, bombs, mines, warheads, and spray tanks. This took place at seven filling plants, five of the army and two in air munitions facilities. Gaseous and particularly dangerous modern warfare agents were filled in the chemical factories where they were produced. This article is based on extensive research in the context of the investigation, ongoing since 1979, into former armaments sites, the methodology of which will be briefly outlined. It will be shown that the effects of chemical warfare agents—their production and deployment at the frontline—continue to pose a risk 100 years later. In consideration of general public health, the disposal of these agents of must be prioritized. Also in Germany, these agents have been exploded, burned, and buried, and the residues pose environmental risks. Some of the demolition sites of these agents are still unknown today.

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1 Introduction

The importance of chemistry and the chemical industry to human well being and prosperity has grown constantly since the mid-nineteenth century. The discoveries of this science are, however, also suited to improving weapons and other armaments employed by states against one another in conflicts.

Whereas the war of 1870–71 was still fought on the German side with around 2,000 metric tons of gunpowder for propellant and explosives (ca. 26 million rounds of infantry munition and ca. 845,000 rounds of artillery munition) (*Der deutsch-französische Krieg* 1881, 816–19), the situation changed crucially with the development of Granatfüllung 88 (Grf. 88 = picric acid) in 1888 and of Füllpulver 02 (Fp 02 = trinitrotoluol) in 1902. It was no longer gunpowder factories that were providing propellant and explosives but rather the private chemical industry. Over the course of the First World War, 33 predominantly private factories in Germany produced 510,000 metric tons of explosives and 36 factories 285,000 metric tons of propellant. Seven chemical factories manufactured 47,400 metric tons of chemical warfare agents. In addition, around 450,000 metric tons of intermediate products were required, some of which were taken from limited food supplies for the population (see Table 1).

In Germany during the Second World War, war-related chemical production increased to 977,500 metric tons of explosives (28 factories), 974,000 metric tons of propellant (43 factories), and 69,500 metric tons of chemical warfare agents (10 factories) as well as around 805,000 metric tons of intermediate products (see Table 1 and Table 2).

This increase in production was made possible by, among other things, the method Fritz Haber and Carl Bosch developed in the early twentieth century to synthesize ammonia, which was honored with a Nobel Prize and made it unnecessary to import saltpeter from Chile for fertilizer and as a raw material to produce munitions. Over a period of just under seventy-five years the production of explosives and propellants in Germany increased by a factor of 975.

Even today, the legacies of both world wars have considerable negative significance for the livelihoods of the population, considering that military chemical substances contaminate the soil and ground water in many locations and unexploded munitions pose a threat to public safety.

Table 1 Quantities of propellant and explosives produced for the wars of 1870–71, 1914–18, and 1939–45 (in Metric Tons) (*Der deutsch-französische Krieg* 1881, 816–19; Preuss and Schneider 2005, 31–47, supplemented)

	Explosives	Gunpowder	Chemical agents	Total
War of 1870–71	–	ca. 2000	–	2000
First World War	508,198	284,808	47,395	840,401
	33 factories	36 factories	7 factories	76 factories
Second World War	977,492	974,188	69,500	2,021,180
	28 factories	43 factories	10 factories	81 factories

Table 2 Production sites for chemical warfare agents and quantities produced in the First and Second World Wars (Preuss and Schneider 2005, 36–37, supplemented)

Site (WW I)	Company	Quantity	Site (WW II)	Company	Quantity	Products
Berlin-Adlershof	Kahlbaum	935	Ammendorf	Orgacid	25,976	Mustard gas
Frankfurt	Farbwerke	12,877	Berlin-Haselhorst	Lonal	1455	Clark, Dora
Leverkusen	Bayer	19,033	Dyhernfurth	Anorgana	12,753	Tabun
Ludwigshafen	BASF	288	Gendorf	Anorgana	4110	Mustard gas
Mainkur	Casella	1042	Hüls	Chemische Werke Hüls	62	Mustard gas
Offenbach	Griesheim-Elektron	950	Ludwigshafen	IG Farben	1180	Phosgene
Wolfen	Agfa	2770	Seelze	Riedel de Haen	7139	Chloroacetophenone
	Total	47,395	Stassfurt	Ergethan	8224	Arsine
			Uerdingen	IG Farben	3881	Adamsite
			Wolfen	IG Farben	4720	Phosgene
				Total	69,500	

As the cleanup of the former munitions site of Stadtallendorf, near Marburg in the region of Hesse demonstrates, the cleanup of a single munitions waste site can cost taxpayers 160 million euros (Reile 2005, 424).

Since the mid-1980s, former munitions sites in Germany have been tested for waste. The tipping point was September 6, 1979, when an explosion in the basement of a residence in Hamburg caused the death of a child. The explosion was caused by chemicals from the abandoned Chemische Fabrik Dr. Hugo Stoltzenberg. The subsequent investigations revealed that munitions, incendiary materials, and chemical warfare agents were present in large quantities there (Scholz 2004; Brauch and Müller 1985, 331–59). At the time, the Bundesarchiv (Federal Archives) was tasked with researching whether similar events—but especially the occurrence of chemical warfare agents—was also possible in other locations.[1]

The weekly magazine *Stern* published the results of its own research, which roused the authorities and the citizens. Politicians discovered the topic and funds were made available to study waste sites. In the 1980s, the munitions waste sites of Hessisch-Lichtenau and Stadtallendorf in Hesse were studied first and a survey was conducted (König and Schneider 1985; Preuss 1990; Preuss et al. 1992a). Even earlier Lower Saxony had begun conducting a survey of munitions waste sites and organized the first conference of experts in the field in 1989.

As part of the environmental research plan of the Bundesminister für Umwelt, Naturschutz und Reaktorsicherheit (Federal Minister for the Environment, Nature Conservation, and Nuclear Safety), research projects were launched to take stock of suspected locations of munitions wastes in Germany. They provided comprehensive lists of sites, studied materials on typical combinations of explosives and chemical warfare agents, and compiled finding aids for federal and state archives (see Thieme 1996). This work provided a practical entry point to the complex theme of "munitions wastes." The Umweltbundesamt (UBA, German Environmental Agency) also supported and assisted exemplary research and study projects in which the guidelines that had been developed could be tested for feasibility. We were able to carry out one such exemplary study (Preuss et al. 2002).

In addition to these UBA programs, handbooks and waste studies were published by the German states (Preuss and Eitelberg 1996) and information gathered on international experience with collecting data, studying, evaluating, and cleaning up the waste of former sites of the armaments industry and the military (Schaefer et al. 1997, 139–44). For federal sites, the process is divided into three phases:

Phase I: Collecting data and initial analysis. This consists of studying the historical development and use of a site and reviewing as applicable the resulting suspicion of waste and describing the site and suspect areas. To that end, the relevant authorities and eyewitnesses are interviewed and promising archives in Germany and abroad visited. In addition to federal archives, state archives,

[1]Bundesarchive Koblenz und Freiburg, "Fertigung, Lagerung und Beseitigung chemischer Kampfstoffe unter besonderer Berücksichtigung des Territoriums der Bundesrepublik Deutschland," 1979, Preuss private collection.

municipal archives, local history museums, and residents with an interest in history can be important sources. Not infrequently, the companies that operated former munitions factories have documentation. Maps, building plans, building descriptions, descriptions of production, production figures, and aerial photographs are also evaluated. Although the client does not always want this, it can make sense to visit the site and make an initial assessment of the potential risk to the protected property. Occasionally, this revealed that immediate action was required.

Phase II: Risk assessment. Risk assessment is based on two steps: orientation studies (Phase IIa) and detailed studies (Phase IIb). The goal of Phase IIa is either to disprove the suspicion of the presence of waste through limited site studies or to confirm that suspicion through studies of the presence of hazardous materials, their release and spread, and their effects on the protected property. On former munitions and military sites, the presence of chemical agents is often suspected, so that the sites to be studied first have to be cleared before disturbing the soil. Chemical weapons and hazardous materials also necessitate that a work safety plan be prepared. In addition to suspect areas typical of the site, such as facilities for smelting, mixing, and casting in munitions filling factories or sewage facilities, in many cases a suspicion arises immediately upon entering owing to the presence of munition parts, residues of explosives, and traces of decontaminants or other chemicals. This suspicion can be checked with quick tests or laboratory analysis of soil and material samples. Phase IIa also calls for conducting groundwater studies downstream from potential waste concentrations and, regarding the type of hazardous materials, studies of soil gases. If the initial suspicion is disproven, the area can be removed from the study program. If the initial suspicion is confirmed or the studies are not yet sufficient, in Phase IIb (detailed studies) a program appropriate to the type and extent of the measures based on earlier findings must be worked out. The objective is to contain and assess the contamination in media that can spread it such as soil, groundwater, and soil gases and to assess the risk to the protected property and to make recommendations for further action. If Phase IIb should reveal the necessity for an immediate measure, it must be implemented without delay. If it should reveal the necessity for a safety or cleanup measure (Phase III), additional site studies for these areas may be necessary until it is possible to develop a comprehensive project proposal that addresses all of the questions relevant to a local measure. In practice, moreover, studies that could be conducted in the context of dissertations have also been necessary (see Szöcs 1999; Bausinger 2007; Mense-Stefan 2005).

Figure 1 shows the relevant sites for the production, processing, and storage of chemical warfare agents (see also Tables 2 and 3). In preparation for war, production plants were built and operated in a secret collaboration between the Oberkommando des Heeres (OKH; Supreme High Command of the Army) and companies from the chemical industry. With few exceptions munitions with chemical warfare agents were filled by five munitions plants of the army and two of the air force. Phosgene, which is a gas at room temperature, was filled directly into bombs at the production plants in Wolfen and Ludwigshafen. For safety reasons, the modern nerve gas tabun was filled in bombs and shells in the factory in Dyhernfurth (now Brzeg Dolny), near Breslau (now Wrocław) where it was produced.

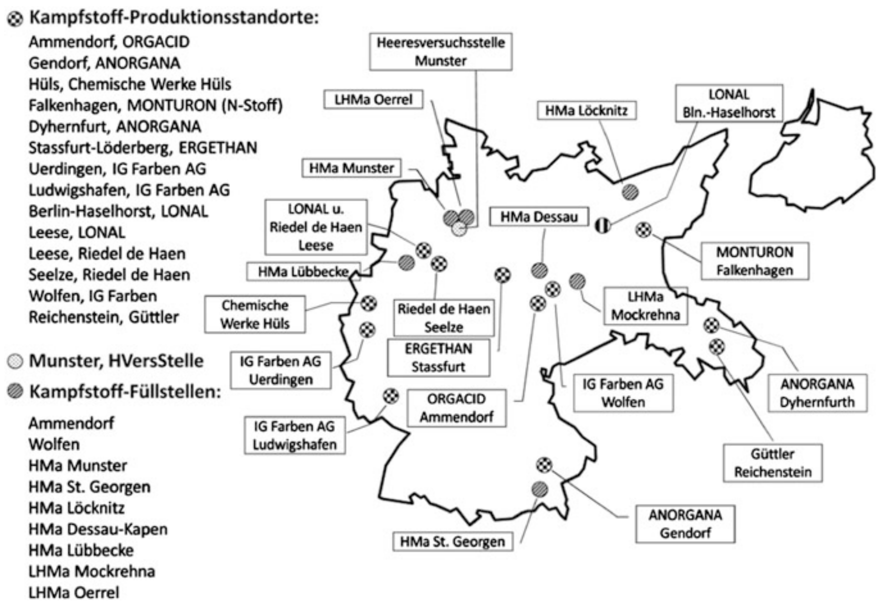

Fig. 1 Working production and filling sites in the Second World War (Kampfstoff-Produktionsstandort (Chemical agents production sites) Munster, HVersStelle [Heeresversuchsstelle] (Munster, army testing site) Kampfstoff-Füllstellen (Chemical munition filling sites))

Table 3 lists 24 production sites for chemical warfare agents, of which just 13 produced a total of 69,500 tons of chemical warfare agents. Five sites were operated directly by private companies; two of them in Ludwigshafen and two in Uerdingen which belonged to IG Farbenindustrie A.G. The necessary intermediate products were already available there. The fifth factory was Riedel de Haen in Seelze, near Hanover.

As part of the collaboration between the OKH and various companies from the chemical industry, 19 plants were built. The army-owned holding company Montan mediated between the contract partners.

Montan was founded in 1916 as Verwertungsgesellschaft für Montanindustrie GmbH:

> §1 Messrs. geh[eimer] Kommerzienrat [Privy Commercial Councilor] Ernst Fromm and Dr. Otto Kahn hereby establish a company with limited liability under the name *Verwertungsgesellschaft für Montanindustrie, Gesellschaft mit beschränkter Haftung*. §2 Company headquarters are in Munich. §3 The objective of the company is to acquire mining rights, shares in unions, mining shares, the commercialization of such rights and assets, and participation in similar companies.[2]

[2]Justizrat (Legal Councilor) Franz Pündtner, notary in Munich, Articles of association, February 3, 1916, notarized copy, reg. no. 180, Preuss private collection.

Table 3 Factories for chemical warfare agents in the former German Reich (1935–1945). (Preuss and Schneider 2005, 36–37, supplemented = PS); and (Ehmann 1948, 720–40 = E)

Type, material	Company, location	Completed	Remark	Owner	Capacity (metric tons monthly)	Total production (metric tons)	Source
White ring (omega salt)							
Phenacyl chloride	Riedel de Haen, Seelze	1935–42	Closed in 1942	Riedel de Haen	140	4006	PS
Phenacyl chloride	IG Farben AG, Ludwigshafen	1935–44	Intermediate product in Ludwigshafen, destroyed in 1944	IG Farben AG	70	3133	E
	Chem. Fabrik Hahnenberg, Leese	1942	Subsidiary of Riedel de Haen	Montan	500	Not in operation	E
Green ring							
Phosgene (F-Oel)	IG Farben AG, Wolfen	1940–1942	Filling of bombs at production site	Montan	400 (filling)	4720	PS
	IG Farben AG, Ludwigshafen	1942	Filling of bombs at production site	IG Farben AG	120 (filling)	1180	PS
	IG Farben AG, Uerdingen	1942	Filling of bombs at production site	IG Farben AG	180 (filling)	Not in operation	E
	IG Farben AG, Auschwitz	–	Planning	Montan	700	Not built	E
Nitrogen Mustard Gas/T 9/N-Lost	Orgacid, Ammendorf, near Halle/Saale	1937	Subsidiary of Auergesellschaft AG and Th. Goldschmitt AG	Montan	50	1928	PS
Tabun (T 83)	Anorgana GmbH, Dyhernfurth	1942	Subsidiary of IG Farben AG, filling of bombs and shells	Montan	1000	12,753	PS

(continued)

Table 3 (continued)

Type, material	Company, location	Completed	Remark	Owner	Capacity (metric tons monthly)	Total production (metric tons)	Source
Sarin (T46)	Anorgana GmbH, Dyhernfurth	Under construction	Subsidiary of IG Farben AG	Montan	100	Not finished	E
	Monturon GmbH, Falkenhagen	Under construction	Joint operation of Montan and IG Farben AG	Montan	500	Not finished	E
Cyanogen chloride (T150)	Anorgana GmbH, Dyhernfurth	1943–44	Subsidiary of IG Farben AG	Montan	20	?	E
Hydrogen cyanide (T155)	Anorgana GmbH, Dyhernfurth	1943–44	Subsidiary of IG Farben AG	Montan	20	?	E
Bi IV 99 (T 300)	Anorgana GmbH, Dyhernfurth	1944	Subsidiary of IG Farben AG	Montan	100	Construction halted	E
Arsine							
Blue ring							
Adamsite (Azin)	IG Farben AG, Uerdingen	1940–44	Intermediate product in Uerdingen, demolished in 1944	IG Farben AG	200	3881	PS
Clark I (C I)	Lonal-Werke, Berlin-Haselhorst	1940	Prof. Dr. Engelhard	Montan	90	1396	PS
Clark II (CII, Dora)	Lonal-Werke, Berlin-Haselhorst	1940	Prof. Dr. Engelhard, Production for experiments	Montan	45	59	PS
Blue-yellow ring							
Arsine oil (As Oel)	Ergethan GmbH, Stassfurth	1938	Subsidiary of Auergesellschaft and Kalichemie AG	Montan	270	8224	PS
	Lonal-Werke, Leese	1940–41	Prof. Dr. Engelhard	Montan	400	Not in operation	E

(continued)

Table 3 (continued)

Type, material	Company, location	Completed	Remark	Owner	Capacity (metric tons monthly)	Total production (metric tons)	Source
Yellow ring							
Oxol-Lost (O)	Orgacid GmbH, Ammendorf, Halle/Saale	1936	Subsidiary of Auergesellschaft AG and Th. Goldschmitt AG	Montan	700	24,048 18,045 OL, 5,739 OKM, 264 OB.	PS
	Anorgana GmbH, Gendorf	1941	Subsidiary of IG Farben AG	Montan	800	Not in operation	E
	Chemische Werke Hüls GmbH, Marl	1941/42	Chemische Werke Hüls GmbH	Montan	600	62 test operation in 1942	PS
Direkt-Lost (D)	Anorgana GmbH, Gendorf	1943	Subsidiary of IG Farben AG	Montan	1500	4,110	PS
	Chemische Werke Hüls GmbH, Marl	1943	Reich-owned experimental plant	Montan	200	Test operation in 1943	E
					Total:	69,500	PS

Very soon thereafter it was in the hands of the Eisenwerksgesellschaft Maximilianshütte, Sulzbach-Rosenberg. In 1934 the Geräte- und Apparate Handelsgesellschaft (GERAP) in Berlin acquired ninety-five percent of the shares. That same year the Reich Ministry of War purchased the shelf corporation Montan from GERAP and Maxhütte (Preuss and Schneider 2005, 25–26). The sale had probably been arranged by the former internal corporate auditor of Maxhütte: the businessman Dr. Johann Martin, known as Dr. Max Zeidelhack,[3] who in early 1934 had transferred to the Heereswaffenamt (HWa; Army Weapons Agency) of the OKH with the rank of Regierungsrat (Senior Civil Servant). Zeidelhack rose to the rank of Ministerialdirigent (Ministerial Director) by 1940. He headed Montan as its first chief executive officer from 1935 to 1942.[4] During this period, 108 army-owned businesses with 180,000 employees were assembled under Montan's roof, with invested capital of 4.5 billion reichsmarks and a turnover of 1.8 billion reichsmarks in 1942. According to a curriculum vitae in tabular form of 1948, Zeidelhack was born in Bayreuth in 1891. He completed secondary school in Ingolstadt and studied six semesters in Munich (German, History of economics, English, French) before the First World War.

Zeidelhack then served as a lieutenant in the reserve of the Bayerische Schwere Artillerie (Bavarian Heavy Artillery); later he served as first lieutenant, pilot, and fighter pilot. After the war he continued his studies in Munich in the subjects of law and political science, graduating in 1922 and receiving his doctorate. After an apprenticeship in a bank, he worked as an auditor. On January 1, 1934, he began work as a business and contract consultant at the Heereswaffenamt of the Reichswehrministerium (Reich Defense Ministry). From November 1, 1934, he was Oberregierungsrat and head of the department of business administration with responsibility for all the financial contracts with German and foreign industry, in particular for army-owned companies as well as for trust companies and Montan. By his own account, he was dismissed from his Ministerialdirigent post on January 14, 1943, by Reichsminister für Bewaffnung und Munition (Reich Minister for Weapons and Munition) Albert Speer, because he was not prepared to sell the army-owned companies for "a fifth of their share value to friends of the minister in the party." After the war, as part of de-Nazification, Zeidelhack was ranked as a "fellow traveler" (*Mitläufer*) by Spruchkammer [Sentencing Chamber] VII in Munich and on January 30, 1948, benefited from the Christmas amnesty.

Montan's task was to acquire properties and plants in trust for the OKH/HWa and to supervise the construction and operation of factories. In order to camouflage them, the factories appeared on Montan's balance sheets and were thus not immediately recognizable as the property of the Reich. The relationships between

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[3]Lebenslauf Max Zeidelhack, March 27, 1948, Bayerisches Hauptstaatsarchiv, Munich, Office of Military Government, Bavaria, 13/83-2/5, as well as National Archives, Washington, DC: Microfilm Publication 12065 Sect. 3-402/NNDG no. 775037.

[4]Wehrmacht-Fernsprechverzeichnis [Army Telephone Records] for Greater Berlin, part I, p. 147, February 1, 1943, Dr. Zeidelhack, department head, business administration (Wa Z 3), National Archives, Washington DC., Microfilm T-77, reel 342.

the OKH, Montan, the companies, and the subsidiaries to be founded were regulated by the master or framework agreement and the lease agreement. Under these agreements, the company could produce without capital or risk and profit from the agreements. Shortly before the end of the war, the Reichsminister für Rüstungs- und Kriegsproduktion transferred nearly all of the shares to Montan as free property (Preuss and Schneider 2005, 23–24).

During the postwar period, the factories were demolished and many buildings and plants suitable for armaments were blown up. Refugees were housed in several former factories in West Germany, which led to the founding of the so-called New Cities (e.g., Stadtallendorf, Waldkraiburg, Geretsried, Espelkamp and Traunreut) (Preuss 1990, Preuss et al. 1992a, 1994; Preuss and Eitelberg 2009, 91–115).

In some cases, the occupying troops used the facilities for their own ends. Other munitions plants are even now collections of ruins and rubble in forests that have become shrouded in myths (e.g., Clausthal-Zellerfeld, Reinsdorf, Forst) (Preuss et al. 1993; Bausinger et al. 2005).

Against this backdrop, in what follows we will discuss three factories for the production of chemical warfare agents: the Orgacid GmbH factory in Ammendorf, near Halle an der Saale; the Monturon GmbH factory in Falkenhagen, near Fürstenwalde; the Anorgana GmbH factory in Dyhernfurth (now Brzeg Dolny) on the Oder River. We will also look at the storage and processing of chemical warfare agents in munitions dumps.

2 The Ammendorf Factory of Orgacid GmbH

Just four kilometers from the center of the city of Halle an der Saale, Germany's largest mustard gas factory lies northeast of Ammendorf. The Ammendorf chemical weapons factory of Orgacid GmbH had a floor area of around twelve hectares. In its final form, it had plants to produce various types of the chemical weapon mustard gas as well as the necessary intermediate products; it also had a plant for filling bombs with chemical warfare agents, which could also be used for shells, and a large storage bunker for O mustard (oxol mustard) and a smaller one for N mustard (nitrogen mustard).

Within a radius of a kilometer around the mustard gas bunker, there were railroad tracks and the buildings for the Buckau chemical factory, which produced chlorine gas, among other things, as well as a sports field, the Rosengarten inn, and residential buildings with gardens, which provided the "ideal" camouflage for this important munitions factory. The toxicologically risky sewage of the factory was routed through Ammendorf parallel to an existing trench in a piped section with fourteen shafts, underneath Hallesche Strasse, Hindenburgstrasse, and Hauptstrasse and along Badstrasse to the Elster River. There was also a detour line with an iron pipe sixty centimeters in diameter, which led into the lower trench and also led to the Elster, which reached the Saale River about two and a half kilometers downstream.

On November 23, 1934, the Degea Aktiengesellschaft (Auergesellschaft), represented by board members Dr. Adolf Gerdes and Dr. Ing. Karl Quasebart, both of Berlin, and the Chemische Fabrik Buckau, represented by its authorized director, Hermann Cordes of Essen, formed a limited liability company called Orgacid GmbH, with headquarters in Berlin. The purpose of the company was the "production and distribution of chemical products of all kinds, especially Orgacid."[5] The chemist Dr. Hermann Engelhard,[6] also of Berlin, was appointed its chief executive office. The company had an supervisory board of three to five members, on which the OKH/HWa was also represented, by Messrs. Zeidelhack and Zahn.[7]

By a resolution of a special general meeting of December 22, 1937, the assets of the Chemische Fabrik Buckau were transferred to Th. Goldschmitt A.G. in Essen. After recording this change in the commercial register, Chemische Fabrik Buckau was dissolved. The party to the contract was now Th. Goldschmitt AG in Essen.[8] On December 10, 1934, within three weeks of signing the articles of association, Orgacid's chief executive officer Engelhard received three preliminary notices from the Waffenamt for contracts to build plants to produce polyglycol M, a conversion plant, and a polyglycol M storage facility in Ammendorf. That meant that the groundwork for the constructing the factory, the ordering of machines, and the setting up of the equipment could begin immediately.[9]

At this time, there was not yet a sales agreement for the property on which the factory was to be constructed. It was not concluded until June 3, 1935. The commercialization company for Montanindustrie GmbH, in Munich, represented by its authorized agent, the businessman Dr. Johann Martin, known as Dr. Max Zeidelhack, from Berlin, then purchased a property in Ammendorf of 75,500 square

[5]Gesellschaftsvertrag: Urkunde Nr. 331/1934, Notar Dr. F. Jacke, November 23, 1934, Preuss private collection.

[6]Engelhard was born in Trier, on November 1, 1896. In August 1914, after taking emergency school leaving exams, he became a soldier at seventeen. After the war he began studying chemistry at the Technische Hochschule in Karlsruhe and completed his degree in Munich. Then from 1921 to 1923 he was working at the Kaiser-Wilhelm-Institut für Physikalische Chemie und Elektro-Chemie in Berlin-Dahlem under Fritz Haber. Under the direction of Haber, he received his doctorate at the TH Karlsruhe with a paper on locating gold in seawater. Subsequently, Engelhard worked at the Auer-Gesellschaft AG. By taking over a teaching position on colloid chemistry at the TH Berlin from 1934, he qualified for an honorary professorship. From 1946, Prof. Engelhard was active at the Physiologisch-Chemisches Institut of the Universität Göttingen. See Lebenslauf von Prof. Dr. H. Engelhard, February 15, 1960, Universitätsarchiv Göttingen, UAG-Kur. 10221. Karl Quasebart has also been employed by Fritz Haber. He explored the Atlantic on a research journey of the Meteor as part of the Gold aus Meerwasser (Gold from Seawater) project (Stoltzenberg 1994, 497).

[7]Wehrmacht-Fernsprechverzeichnis [Army Telephone Records] for Greater Berlin, part I, p. 144, June 6, 1943, Dr. Zahn, department head, business administration, head chemist Wa A. National Archives, Washington, DC., Microfilm T-77, reel 342.

[8]Transcription of the copy from the commercial register, Amtsgericht Halle an der Saale, Department B, December 23, 1937, Preuss private collection.

[9]Entwürfe der Schreiben von Wa B 4 VII an die Orgacid GmbH, December 10, 1934, The National Archives, London, FO1031/204.

meters located between the Chemische Fabrik Buckau grounds and the Dessau–Merseburg train line. The directors of the Buckau factory, Hermann Cordes of Essen and Dr. Camillo Irmscher of Chemische Fabrik Buckau, which still existed at this time, appeared at the signing of the agreement.

On September 20, 1935, the Chemische Fabrik Buckau, Ammendorf; the Degea-Aktiengesellschaft (Auergesellschaft), Berlin; and the German Reich (treasury of the Wehrmacht's department of the army), represented by the Reichskriegsminister (Rkm, Minister of War), signed a legal contract to build a polyglycol factory and a conversion facility.[10] For purposes of secrecy, the agreement had a passage stipulating that the companies were to be active on behalf of and for the account of the Rkm, but in their own names vis-à-vis outsiders. The plant was to take into account the requirements of air defense, with roof constructions to withstand fire bombing and capable of being blacked out. According to Sect. 2, the land and the existing buildings of Orgacid GmbH were to be

> made available on the basis of a lease agreement still to be concluded by the authorized agent of the Rkm and the commercialization company for Montanindustrie GmbH, Munich, into whose possession all new plants that the companies will operate in trust under section 1 will also be transferred after completion and before beginning operation.

Degea/Auergesellschaft and Chemische Fabrik Buckau were permitted to contract their subsidiary Orgacid GmbH to build the factory, with which a lease agreement for operating the factory would be signed as well.

The factory grounds were divided into the following sections of production:

- A-Plant for the production of ethylene oxide, ethylene chloride, polyglycol M, and polyglycol MI.
- B-Plant (old) for the production of Oxol mustard gas (O mustard); winter mustard gas (OKM, OB).
- B-Plant (new) for the production of Oxol mustard gas (O mustard); winter mustard gas (OKM, OB).
- T9 plant for the production of nitrogen mustard gas (N mustard).
- Plant for filling KC 250 Gb bombs.
- Sewerage.

The annual report for the fiscal year 1937–38 reveals that production of polyglycol M, ethylene oxide, and ethylene chloride began in May 1937.[11]

[10]Vertrag zwischen der Chemischen Fabrik Buckau (Ammendorf), der Degea-Aktiengesellschaft (Auergesellschaft), Berlin, und dem Deutschen Reich (Fiskus des Wehrmachtsteils Heer), vertreten durch den Reichskriegsminister (Rkm) über die Errichtung einer Polyglykolfabrik und einer Umsetzungsanlage, September 20, 1935, Preuss private collection.

[11]Orgacid GmbH, Bericht über das Geschäftsjahr 1937–38, December 21, 1938, Preuss private collection.

Table 4 Construction projects for chemical weapons plants managed by the building department of Orgacid GmbH, later Lonal GmbH (Preuss and Eitelberg 2003b, 65)

1937–38	1939	1940–41	1943–44 (Lonal from 1941–42)
Ammendorf	Ammendorf	Ammendorf	Ammendorf
Trostberg	Gendorf	Gendorf	Gendorf
Hahnenberg	Hahnenberg	Hahnenberg	Leese
–	Hörpolding (St. Georgen)	Hörpolding (St. Georgen)	Hörpolding (St. Georgen)
Munster	Munster	Munster	Munster
–	–	–	Oerrel
–	Löcknitz	Löcknitz	Löcknitz
–	–	Dessau (Kapen)	Dessau (Kapen)
–	–	Lübbecke	Lübbecke
–	–	–	Mockrehna

In addition, Orgacid GmbH was granted several construction contracts late in the fiscal year 1937–38 (see Table 4).[12]

The annual report contains no production figures for the fiscal year 1938–39. The report on the events of the fiscal year reads:

> In the new fiscal year the company was contracted to begin producing final products as well. Manufacture began in May [1938] and is slowly increasing. During the critical days of September, the leadership did everything in its power to reach maximum production. Unfortunately, a series of accidents could not be avoided. Now all measures have been taken to reduce such accidents to an absolute minimum.[13]

For the fiscal year 1939–40, the production of various types of mustard gas in B-Plant is documented.[14] A-Plant continued to produce polyglycol M, polyglycol M I, ethylene oxide, and ethylene chloride.

In A-Plant, which was brought into operation in 1939, production was increased after the war began. In B-Plant, 572 metric tons of Oxol mustard gas were produced per month. In the winter of 1939–40, parts of the plants were closed to make repairs. The experimental plant for nitrogen mustard (T 9) was opened without a hitch (Table 5).

Of the 30,148 metric tons of mustard gas produced in the German Reich by the end of the war, 25,976 metric tons (86.2%) were from Ammendorf. In the filling plant in Ammendorf, 61,108 bombs (KC 250 Gb) were filled with ca. 90.2 kg for a total of 5512 metric tons of mustard gas.

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[12]Orgacid GmbH, Bericht über das Geschäftsjahr 1938–39, December 21, 1939, Preuss private collection.

[13]Orgacid GmbH, Bericht über das Geschäftsjahr 1938–39, December 21, 1939, Preuss private collection.

[14]Orgacid GmbH, Bericht über das Geschäftsjahr 1939–40, Preuss private collection.

Table 5 Production of Orgacid GmbH Ammendorf, May 1937–March 1945 (tons, piece)

Time/Production	Eth. ox.	PM	PMI	O Mustard	OB Mustard	OKM Mustard	T 9 Mustard	KC 250 Gb
–	–	–	–	–	–	–	–	–
5/1937–3/1938 (G)	756	2085	–	–	–	–	–	–
4/1938–3/1939 (F)	15	3507	–	2183	–	–	19	–
4/1939–3/1940 (E)		1872	1473	3742	–	1215	118	–
4/1940–3/1941 (E)	669	1828	1481	3476	–	1908	293	6867
4/1941–3/1942 (D)	2,206	827	565	3868		789	361	53,859
4/1942–3/1943 (C)	2,115	1608	396	862	264	399	432	382
4/1943–3/1944 (B)	982	2361	848	2652	–	1030	516	–
4/1944–12/1944 (A)	2,314	248	128	972	–	398	189	–
1/1945–3/1945 (A1)	?	?	?	290	–	–	–	–
5/1937–3/1945	9,057	14,336	4891	18,045	264	5739	1928	61,108
				25,976 tons of mustard gas				

Key: *Eth. ox.* ethylene oxide; *P M* Polyglycol M; *PMI* Polyglycol M I; *OL* Oxol mustard gas; *OB* Winter mustard gas based on S mustard gas/O mustard gas; *OKM* mustard gas and Dichlordipropylsulfid (mixed/winter mustard gas); *T 9* nitrogen mustard gas; *KC 250 Gb* chemical bombs filled with 90.2 kg of mustard gas, of which 47% were sent to L.H.Ma. Mockrehna, 26% to L.Ma. Krappitz, 22% to L.Ma. Domnau, 5% to L.Ma. Regny, and 7 bombs to Munster. Unfilled chemical warfare agents (O mustard gas, N mustard gas) were first delivered to Munster and to H.Ma. Löcknitz. The quantities indicated in Table 5 correspond to deliveries to the OKH. For all products, the exception of KC 250 Gb, there was additonal production and deliveries to private parties, such as IG Farbenindustrie AG, Frankfurt am Main, and the Lonal-Werk GmbH Berlin. Of the 28,800 metric tons of mustard gas produced in the German Reich by the end of the war, 25,976 metric tons (= 86.2%) were from Ammendorf. In the filling plant, 61,108 KC 250 Gb bombs were filled with 5512 metric tons of mustard gas. Table 5 is based on the sources A1–G (Preuss private collection and BArch R 8135/7003 and 7798)

(*A1*) Boyne, J.G., Lanfear, W.E., Calcott, W.S. and P.J. Leaper (1945): Production of Vesicant Agents at Ammendorf. CIOS,Item No. 8, File No. XXXII-7, p. 8. The British Library, Boston Spa, Wetherby, West Yorkshire

(*A*) Report der Orgacid GmbH Ammendorf/Saale District, on the fiscal year 1943–44 and on the current fiscal year (additions through December 1944), 4th version, p. 3, January 1945

(*B*) Report (no. VI/12270) by the Deutsche Revisions- und Treuhand-AG, Berlin on the audit of the annual statement of Orgacid GmbH Ammendorf, near Halle, on March 31, 1944, copy no. 6, p.23

(*C*) Report (no. VI/11517) by the Deutsche Revisions- und Treuhand-AG, Berlin on the audit of the annual statement of Orgacid GmbH Ammendorf/Saale District, on March 31, 1943, copy no. 6, p. 22

(*D*) Report (no. VI/10240) by the Deutsche Revisions- und Treuhand-AG, Berlin on the audit of the annual statement of Orgacid GmbH Berlin, on March 31, 1942, copy no. 6, p.21

(*E*) Report (no. VI/7840) by the Deutsche Revisions- und Treuhand-AG, Berlin on the audit of the annual statement of Orgacid GmbH Berlin, on March 31, 1941, copy no. 11, appendix, p. 28

(*F*) Report (no. 12795) by the Deutsche Revisions- und Treuhand-AG, Berlin on the audit of the annual statement of Orgacid GmbH Berlin, on March 31, 1939, copy no. 6, p. 6 and appendix, p. 21

(*G*) Report (unnumbered) by the Deutsche Revisions- und Treuhand-AG, Berlin on the audit of the annual statement of Orgacid GmbH Berlin, on March 31, 1938, copy no. 7, appendix, p.21

In the fiscal year 1940–41, production of chemical warfare agents continued. Production of Oxol mustard gas and winter mustard gas could not be continued at full capacity because of a shortage of storage space, so it was halted in the months of August and November.[15] Production of T 9 (nitrogen mustard gas) was slowed by inadequate supply of intermediate products. The expansion of the factory was continued.

During the fiscal year 1941–42, Orgacid was split into two divisions. From June 1941, there was Orgacid GmbH, building department, Berlin, and Orgacid GmbH, operations, Ammendorf. The building department was transferred to Lonal-Werke GmbH, Berlin, in October 1941.[16]

Production of mustard gas (OL and OKM) in B-Plant averaged 476 metric tons per month. A shortage of workers caused considerable difficulties. B-Plant had to be closed for three weeks beginning in mid-December 1941 because of health problems among the workers. During the fiscal year 1942–43, A-Plant achieved its highest ever production numbers for ethylene oxide. But production of polygycol M or polygycol M I continued for only five months, so that only 1,608 metric tons could be produced. This led to a considerable decline in production in B-Plant. For that reason, almost no Oxol mustard gas at all was produced in the fiscal year 1942–43. There were 399 metric tons of OKM produced. In addition, preparations for the production of OB were affected, and 230 metric tons were produced as part of an experimental production.

In T 9-Plant, its production capacity of 50 metric tons monthly could not be exploited fully because of reduced supplies of intermediate products.

The filling plant was closed for the entire year, apart from April 1942, because of a lack of orders. In April, 382 bombs were filled.

The expansion of the factory continued in 1943–44. In order to increase production of OB, B-Plant was further expanded. The storeroom of T-9-Plant was enlarged by installing a fourth vat of 120 metric tons.[17]

On April 18 and 19, 1945, Ammendorf was occupied by American troops and guarded by about thirty American soldiers until it could be cleared out later. At this time, stores consisted of 600 metric tons of arsenic powder from Leese and 625 metric tons of mustard gas. When American troops arrived, numerous files and documents were confiscated.[18] That may have been connected with the visit by a CIOS team, which presented an extensive report including plans and process diagrams.[19]

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[15]Orgacid GmbH, Vorläufiger Geschäftsbericht über das Geschäftsjahr 1940–41, from April 1, 1941 to December 31, 1940, p. 1, Preuss private collection.

[16]Orgacid GmbH, Vorläufiger Geschäftsbericht über das Geschäftsjahr 1941–42, from April 1, 1941 to December 31 1941, p. 1, Preuss private collection.

[17]Orgacid GmbH, Bericht über das Geschäftsjahr 1943–44, p. 3, Preuss private collection.

[18]Sekretariat K, Essen, Bericht: Betrifft: Orgacid GmbH Essen, May 28, 1945, Preuss private collection.

[19]Boyne et al. 1945. Production of Vesicant Agents at Ammendorf. M52.D92., CIOS Target No. 8/30 Chemical Warfare, Item No. 8, File No XXXII-7, Combined Intelligence Objectives

It is not known what happened on the grounds during the course of dismantling by the Soviet Military Administration in Germany (Sovyetskaya Voyennaya Administratsya v Germanii, SVAG). The first studies and simple cleanups were carried out in the 1950s.[20] A study by Chemiewerk Kapen, near Dessau, in 1953 produced the following results: Some of several bunkers and underground cisterns were still well preserved, while others had been blown up. A lead-lined iron container with a capacity of 2–3 cubic meters in one part of the facility was found to be contaminated with chemical warfare agents. The former grounds of the filling plant smelled of chemical agents; empty bombs and artillery shells were lying around. The remains of the structure of the filling plant were recognizable. The storage bunker for mustard gas had eight cells. They contained

> ca. 1,400 cubic meters of water with small amounts of mustard gas, including ca. 150 cubic meters of concentrated nitrogen mustard, which forms a layer of insulation from the water above by means of hydrolysis.[21]

Later "ca. 110 metric tons of sulfur mustard were found in the reinforced-steel bunkers," of which 52.5 cubic meters mustard gas were destroyed in Kapen, and 855 cubic meters of neutralized liquids were directed into the Elster. Nearly two years later, tests of the mustard sludge in the cells of the mustard gas storage bunker still had high levels of mustard gas. Substances active in mustard gas represented as much as 50%; thiodigycol, sulfone, and sulfoxide were also found. The water above the sludge had a pH of 1.0.

The final report on measures and determinations from 1956 reads as follows:

> Work was begun on April 16, 1956, and conducted according to the instructions of May 11, 1956. All of the containers and trenches were examined for chemical warfare agents, then decontaminated and filled with gravel. The mustard sludge located in the bunker cells was destroyed by us at the site. […] After emptying the cells, the floors and walls were decontaminated and cleaned. The cell openings were then walled up. It was therefore unnecessary to fill the cells, since the cells are empty and decontaminated. Around 4,000 cubic meters of gravel were moved to fill communication trenches, funnels and pits. Work was completed on December 21, 1956.[22]

It also reported that 75 cubic meters of mustard sludge were neutralized and destroyed between April 1956 and April 1957; 15 cubic meters of mustard sludge were said to have been found in each of the seven bunker cells. Around 50% of the

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(Footnote 19 continued)

Sub-Committee G-2 Division, SHAEF (Rear) APO 413, National Archives, Washington, RG 338 and British Library, Document Supply Center, Boston Spa.

[20]The discussions referred to in what follows are based on Arbeitsberichte Chemie Werk Kapen, p. 1247 (April 17, 1957), p. 1249 (February 11, 1957), p. 1722 (February 2, 1957) sowie Zusammenfassungen von Berichten zwischen dem January 29, 1953, to July 23, 1956, Preuss private collection.

[21]Ibid.

[22]Arbeitsberichte Chemie Werk Kapen, p. 1247 (April 17, 1957), p. 1249 (February 11, 1957), p. 1722 (February 2, 1957), sowie Zusammenfassungen von Berichten zwischen dem January 29, 1953, to July 23, 1956, Preuss private collection.

factory grounds (southern part) were decontaminated; that area was said to be usable under certain conditions. The plan was to close the northern part for fifty years. The situation did not change in the 1960s. According to notes on proposals concerning the problems of the Orgacid buildings made to an advisory committee of the District of Halle on June 6, 1978,[23] the division of the grounds was still recommended, with the northern part to be closed for fifty years (with entry prohibited), but with the involvement of the chemical weapons expert Professor Karlheinz Lohs it was to be further divided into the "bunker area" and the "remainder of the northern part." Permission was granted to add soil to a height of at least three meters, on which it was said to be possible to build without a foundation. The conditions in the southern part were unchanged. The area around the factory up to a distance of 50 meters were included in these measures.[23] In February 1990, members of the officers' college of the ground forces of the Nationale Volksarmee (NVA; National People's Army) in Löbau-Zittau visited the city of Halle.[24] The subject of the visit was "guaranteeing order and safety on the former site of Orgacid, Halle-Ammendorf." One of them was the chemical weapons expert Colonel Professor Siegfried Franke, who had already been involved in the decontamination efforts of the Chemie-Werk Kapen. He explained that chemical warfare agents had still been present only in the mustard gas bunker, but they had been completely removed. At the time, sulfur mustard had been found but not nitrogen mustard or arsenic. Based on this assessment of the situation, it seemed necessary to the participants of the event to "rethink earlier arrangements."[25]

Additional site studies have been conducted since 1990 (Fig. 2, Table 6).

3 The History of Falkenhagen Factory of Monturon GmbH, Development, the Structure of the Buildings, and Production

The following text is based on an assessment of the Falkenhagen factory of Monturon GmbH as part of an investigation of this former munition site (Preuss and Eitelberg 1994).

The area of around nine square kilometers where the former factory grounds of the "Seewerk" Falkenhagen (Falkenhagen "Lake Factory") of Monturon GmbH are located is around 40 km east of Berlin and 10 km west of Frankfurt an der Oder, in the forested area of the Falkenhagener Heide (Falkenhagen Heath) between Falkenhagen to the west, Döbberin to the northeast, and Petershagen to the south.

[23]Niederschrift zur Beratung über die Problematik Orgacid-Gebäude, June 6, 1978, District Council of Halle, Preuss private collection.

[24]Aktennotiz zum Besuch der Offiziershochschule Löbau-Zittau der Landstreitkräfte der NVA, February 21, 1990, Preuss private collection.

[25]Ibid.

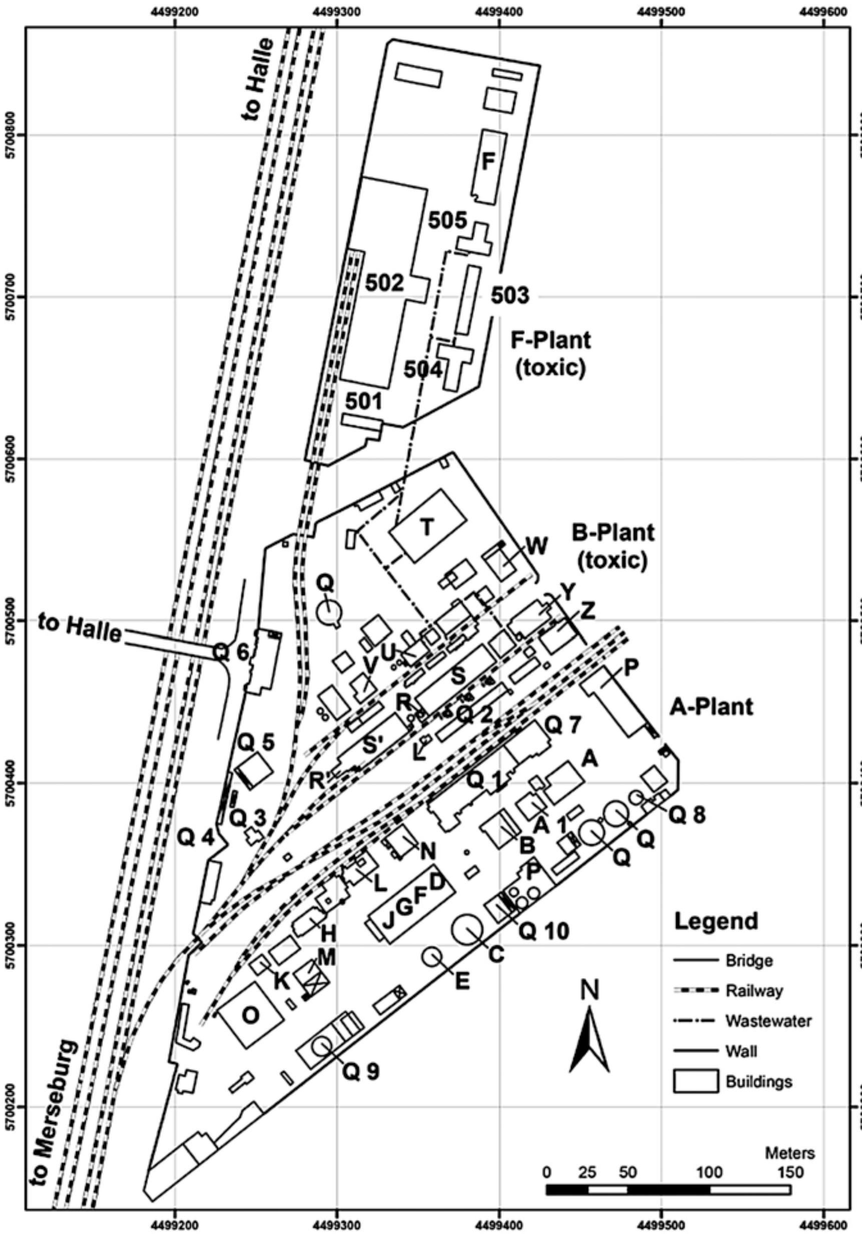

Fig. 2 Layout of Orgacid GmbH Ammendorf (Werkspläne von 1922–1928; Old building fabric, factory plan, A-Plant, 1935, Preuss private collection; Factory plan of 1940, scale 1:500: F-Plant (filling plant); Factory plan of May 1940, revised by VEB Chem. Werke Buna, Schkoppau, 1977; Factory plan of autumn 1942, scale 1:500: Reichsbahnanschluss Orgacid GmbH Ammendorf, Preuss private collection. Boyne, J.G., E.W. Lanfear, W.S. Calcott and P.J. Leaper. 1945. Production of Vesicant Agents at Ammendorf. M52.D92., CIOS Target No. 8/30 Chemical Warfare, Item No.8, File No. XXXII-7, Combined Intelligence Objektives Sub-Committee G-2 Division, SHAEF (Rear) APO 413, National Archives, Washington DC., RG 338 and British Library, Document Supply Center, Boston Spa, Weatherby, West Yorkshire)

Table 6 Inventory of buildings: Orgacid GmbH Ammendorf

Plant	Building No.	Function
A-plant	A/II	Alcohol rectification and storage
	A1/II	Alcohol storage
	B/I	Ethylene furnaces
	C/XIV	Ethylene storage
	D/XIX	Ethylene purification
	E/XV	Ethylene storage (pure), 1000 m^3
	F/XIX	Chlorhydrine manufacture
	G/XIX	Ethylene oxide manufacture
	H/XVIII	Ethylene oxide storage
	J/XIX	Thiodiglycol manufacture
	K/-	Sulfur storage
	L/XVII	Chlorine storage
	M/-	Hydrogen sulfide manufacture
	N/XVI	Lime slaking and solution
	O/X	Neutralization, waste treatment
	P/II, VII, VIII	Thiodiglycol storage
	P/-	Thiodiglycol storage
	Q/XI	Hydrogen storage
	Q/XII	Storage, 3000 m^3
	Q1/-	Washrooms and changing rooms, decontamination
	Q2/-	First aid
	Q3/-	Guard room
	Q4/-	Main gate
	Q5/-	Stores
	Q6/-	Administration offices
	Q7/IX	Workshop, warehouse
	Q8/XIII	Storage, 200 m^3
	Q9/XXI	Cooling tower
	Q10/XXIII	Warehouse
B-plant	R/-	Hydrogen chloride burners
	R´/-	Hydrogen chloride burners
	S/-	Mustard gas reactor
	S´/-	Mustard gas reactor
	T/-	Mustard gas storage
	U	Decontamination of toxic wastes
	V	Nontoxic wastes
	W/-	Triethanolamin-thionylchloride reactors(T-9)
	X/-	Soda storage and solution
	Y/-	T-9 neutralization, etc.
	Z/-	T-9 storage

(continued)

Table 6 (continued)

Plant	Building No.	Function
F-plant	501	Administration office
	502	Large aboveground workshop with charging machines
	503	Common rooms with kitchen
	504	Washrooms and changing rooms, nontoxic
	505	Washrooms and changing rooms, toxic
	F	Static water tank

Werkspläne von 1922-1928, Gebäudealtbestand, Werksplan A-Anlage, 1935; Werksplan von 1940, scale 1:500: F-Plant (filling plant); Werksplan vom May 1940, revised by VEB Chem. Werke Buna, Schkoppau, 1977; Werksplan vom Herbst 1942, scale 1:500: Reichsbahnanschluss Orgacid GmbH Ammendorf, Preuss private collection; Boyne, J.G., E.W. Lanfear, W.S. Calcott and P.J. Leaper. 1945. Production of Vesicant Agents at Ammendorf. M52.D92., CIOS Target No. 8/30 Chemical Warfare, Item No. 8, File No. XXXII-7, Combined Intelligence Objektives Sub-Committee G-2 Division, SHAEF (Rear) APO 413, National Archives, Washington, RG 338 and British Library, Document Supply Center, Boston Spa, Wetherby, West Yorkshire

In the Falkenhagener Heide in November 1938, groundwork was begun for the building of an industrial site to produce the incendiary material chlorine trifluoride (ClF_3) (code name N-Stoff [Substance N]). According to a decision in May 1942, another large facility for sarin production was to be built in the same location.[26] This construction project was set to begin in September 1943. In contrast to the cramped site of the Orgacid factory in Ammendorf, the grounds on the Falkenhagener Heide were oversized. The history of the factory's development and its background were presented in detail by Schmaltz (2005) under the motto "Wunderwaffe N-Stoff" (N Substance: The Miracle Weapon). It was crucial that Hitler was fascinated by this particular incendiary material and had great hopes for it. On the other hand, there must have been a group of interested parties behind the project that made it possible for more than 60 million reichsmarks to have been spent already by the end of March 1944 without any N-Stoff being produced. At the same time, the competition between the research department of the Heereswaffenamt and the laboratories of IG Farbenindustrie AG also played a role, as did competition with the increasingly powerful SS later.

The Forschungsabteilung des Waffenamtes (WaF; Research Department of the Weapons Agency) was engaged in November 1938 to immediately begin groundwork for a new facility in Falkenhagen (Muna-Ost [Muna East] or M.O.) (Schmaltz 2005, 152). Owing to the project's urgency, the acquisition of the site and the construction were to be handled by Montan or carried out under its control.[27]

[26] Klenck, Jürgen E. von "History of the 'Seewerk' (Falkenhagen)" 26. March 1945, p. 1/69. The National Archives, London, WO 208/2186.

[27] Schreiben der Waffenamt-Forschungsabteilung (WaF) an den Chef Wa J Rü betreffend Muna-Ost, December 1938, Preuss private collection.

From mid-May 1943, there were plans to produce the new chemical weapon sarin in a large facility (500 metric tons monthly) in Falkenhagen (Schmaltz 2005, 159). That decision was preceded by an order to transfer Falkenhagen to IG Farben by February 12, 1943. The head of the agency, General Leeb, wanted Professor Thiessen of the Kaiser Wilhelm Institute to participate in a preliminary discussion on this.[28] The construction and management of this large facility exceeded the capabilities of the Waffenamt's research department, so the Falkenhagen construction site was transferred to IG Farbenindustrie AG or more precisely to its Turon GmbH subsidiary on September 1, 1943, after the transfer of the Falkenhagen construction site had been discussed at the site itself on July 23, 1943.[29] Turon was still in the process of being founded at this time. The legal form was the lease agreement of September 1, 1943, which concerned the factory and all its associated facilities. Only the forest and the management thereof remained in the hands of Montan.[30] On September 3, 1943, Turon GmbH was founded, with headquarters in Ludwigshafen. The share capital of the company was split equally between Montan Industriewerke GmbH and IG Farbenindustrie AG. Turon was later renamed Monturon to avoid a confusion of names.[31] The chief executive officer of Monturon was Director Dr. Otto Ambros; his representative was Dr. Jürgen E. von Klenck; von Klenck, chief engineer Bilfinger, and Röhr (MBA) were named as internal auditors.[32]

The significance of the new product sarin is clear from a report on the production of chemical warfare agents of February 1, 1944.[33] In addition to the experimental facility in Heidkrug, near Munster (capacity 40 metric tons monthly), two expansion stages were constructed at this time following different procedures. These were the experimental facility Sarin I in Dyhernfurth with 100 metric tons monthly and

[28] Chef des Stabes (Scholz) an WaF, Betr.: Sondervorhaben Falkenhagen, February 2, 1943, Preuss private collection.

[29] Aktenotiz des Wa J Rü (Mun) - Az. 70 o 40-19 Wa J Rü/Mun 3 zbV/IX; Nr. 1320/43 g.Kdos. betreffend die Ausweichstelle des Reichsamtes für Wirtschaftsausbau in Falkenhagen, July 26, 1943, Preuss private collection.

[30] Schreiben von Oberst a.D. Hammer, Falkenhagen an die Verwertungsgesellschaft für Montanindustrie GmbH, München, September 18, 1943, Preuss private collection.

[31] Monturon GmbH. Abschlussbericht, 1943–44, Fabrikhauptbuch Seewerk, Preuss private collection, and Schmaltz 2005, 160 n. 520.

[32] Dr. von Klenck was born in Bromberg on June 8, 1909. He attended school in Frankfurt am Main, Frankfurt an der Oder, Berlin, and Cologne. After graduating secondary school, he studied chemistry in Cologne and Göttingen. In December 1933 he passed his doctoral exams under Professor Thiessen. His first position was at IG Farbenindustrie A.G. in Höchst. From 1935 to 1940 he was a member of the Allgemeine SS in Frankfurt. He claimed to have been a lieutenant with the 29th flak regiment (Frankfurt) from the time the war broke out. In February 1942 he was conscripted to work at IG Farbenindustrie in Ludwigshafen and was appointed vice deputy director of Monturon in Falkenhagen (Seewerk). He experienced the end of the war in the Anorgana factory in Gendorf, where he was arrested on May 20, 1945, because of his previous membership in the SS and transferred to Dustbin, Enemy Personnel Exploitation Section, FIAT, Control Commission for Germany (BE), B.A.O.R. In FIAT EP 254–84 (von Klenck), December 14, 1945, Interrogation Report, p. 5. The National Archives, London, FO 1031/97.

[33] "Deutsche Kampfstoff-Produktion, Ludwigshafen am Rhein," February 1, 1944, BArch R3/1894, p. 6.

the large facility Sarin II in Falkenhagen with 500 metric tons monthly. The large facility in Falkenhagen had a planned budget of ca. 44 million reichsmarks,[34] of which 380,000 reichsmarks had been spent by January 1944. The planned start date was "mid-1945." These anticipated costs for the sarin plant contrast starkly with the cost value of the Falkenhagen N-Stoff factory reported on March 31,1944.[35] At that time it was more than 61 million reichsmarks. This recalls the mismanagement in the production of infantry munitions, whose production in 1939–40 was reduced in the middle of the war at one third (Preuss and Eitelberg 2010, 185–89).

The involvement of IG Farbenindustrie AG is also evident in the draft agreement of June 13, 1944, between the German Reich (office of the army), the Verwertungs gesellschaft für Montanindustrie GmbH, IG Farbenindustrie AG, and Monturon GmbH concerning the expansion of the N-Stoff plant of the OKH by adding a fabrication facility to produce 500 metric tons monthly of sarin.[36] According to that contract, IG Farben was also supposed to determine how the N-Stoff plant with provisional capacity of 10 to 15 metric tons monthly could be put into operation.

Precisely a year after the deadline for preparations to transfer the Falkenhagen factory to Monturon, matters took an astonishing turn. On July 23, 1944, the building inspector Glupe (Wa F), who was responsible for the opening of the N-Stoff plant, arrived in the company of SS officers and handed Monturon's management a letter from the brigade leader Dr. Otto Schwab (head of the technical office in the main office of the SS leadership) (SS-Führungs-Hauptamt) that read as follows:

> With reference to the order, known to you, from the Führer and head of OKH 1731/44 of July 7, 1944, you are hereby informed that the Führer also ordered that the N-Stoff factory be taken over immediately by the Waffen SS. The agreements between the Heeres-Waffenamt and IG Farben are to be annulled effective immediately and measures already undertaken reversed. […] Its seamless transfer […] is the responsibility of the current head of the factory, Dr. Glupe.[37]

The expansion was to be continued; the production of N-Stoff was to begin in August 1944.[38] The new owners, the Waffen-SS, wanted the N-Stoff facility to be under the direction of Dr. Siegfried Glupe, a former employee of the

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[34]Entwurf eines Bau- und Errichtungsauftrages für die Errichtung der Sarin II Anlage in Seewerk (Auftrags-Nr. 3/IX-4888-9026/43). The National Archives, London, FO 1031/179.

[35]MONTURON GmbH, Aufstellung des Buchwertes zum 31.03.1944 (= Anschaffungswert 1944), Werk Falkenhagen, Preuss private collection.

[36]Draft agreement: Vertrag zwischen dem Deutschen Reich (Wehrmachtsfiskus), vertreten durch das Oberkommando des Heeres (OKH), der Verwertungsgesellschaft für Montanindustrie GmbH, der IG Farbenindustrie AG und der Monturon GmbH über die Erweiterung der OKH-eigenen N-Stoff-Anlage durch eine Fabrikationsstätte zur Herstellung von 500 moto Sarin, June 3, 1944, Preuss private collection.

[37]Monturon to the Verwertungsgesellschaft für Montanindustrie, August 2, 1944, concerning the demand by the SS that the factory in Falkenhagen be transferred, July 23, 1944, Preuss private collection. The letter is from Director Ambros and signed by his representative, v. Klenck. On this, see also Schmaltz (2005, 171).

[38]Aktenvermerk der Montan betreffend Seewerk, July 25, 1944, Preuss private collection.

Kaiser-Wilhelm-Institut für physikalische Chemie und Elektrochemie, whose doctoral advisor had been Prof. Thiessen (Schmaltz 2005, 146). At this time Glupe was section head of the research department of the Heeres-Waffenamt (Wa F, Gruppe IIc) His group leader was Prof. Eschenbach.[39] Glupe guaranteed that ten metric tons would be produced in September. Experimental production seems to have begun in October 1944; a production report from December 1944 mentions a quantity of 5 metric tons produced[40]; according to von Klenck, a total of 22 metric tons were produced.[41]

The end of the Falkenhagen factory is documented by a letter from Monturon GmbH, informing Montan in February 1945 that the N-Plant of the factory had been closed when the Oderbruch became part of the battle zone.[42] It can be assumed that the factory was occupied by Soviet troops by April 19, 1945, at the latest (Griess 1985, 82).

At the instructions of OKH and in agreement with the technical office in the headquarters of the SS, already on February 10, 1945, sixty freight cars with special equipment and machines and five empty tank cars departed for Stulln, Bavaria. After the war Glupe reported that in February 1945 a total of five trains were prepared with goods to be relocated to Stulln, but only four arrived there, and one remained behind in Prague. Other material, he claimed, had been transported to Leese including things from the Anorgana factory in Dyhernfurth.[43] According to a letter from the Luranil-Baugesellschaft mbH, material was also transported from the Falkenhagen construction to the Gendorf factory of GmbH.[44] The company assets belonging to the "Seewerk" Falkenhagen were first seized and later expropriated by the Soviet Military Administration in Germany.[45]

4 Production at the Falkenhagen Factory

Originally, the factory in Falkenhagen was only supposed to produce the incendiary material chlorine trifluoride (N-Stoff). The plan was to have an experimental facility with a monthly capacity of 10 metric tons, which would be increased to 50 metric tons.

[39]Abschrift/Bu. des Fernsprechverzeichnisses des H Wa, Forschungsabteilung (mit Hochschulzentralstelle), z. Zt. Kummersdorf-Schiessplatz, Preuss private collection.

[40]Fertigungsbericht C-Stoff, Fertigung in December 1944, p. 87, BArch R 3/1894.

[41]Klenck, Jürgen E. von, "History of the 'Seewerk' (Falkenhagen)," March 26, 1945, p. 3/71, The National Archives, London, WO 208/2186. The author, von Klenck, was the vice deputy director of Monturon GmbH.

[42]Rundschreiben der Monturon GmbH, Nr. 914/45/IVa1/Pr. an die Montan-Industriewerke GmbH betreffend Betriebsstillegungen und Verlagerungen, February 1945, Preuss private collection.

[43]Aktenvermerk (Nr. 8) der IVG betreffend nach Stulln verlagertes Gut aus Falkenhagen, May 23, 1952, Preuss private collection.

[44]Schreiben der Luranil-Baugesellschaft mbH (in Auflösung) an das IG Farben Control Office (Liquidation section), Frankfurt am Main betreffend Silbermaterial, Frankfurt am Main, January 18, 1951, Preuss private collection.

[45]Verfügung der Landesregierung Brandenburg, Enteignungsurkunde für das beschlagnahmte Betriebsvermögen der Firma M.O. Falkenberg (!), Falkenberg, Kreis Lebus, July 7, 1848, Preuss private collection.

The deadline to begin operations was October 1944 and the total quantity produced 22 metric tons was stated, probably accurately, by the vice deputy director of Monturon, von Klenck.[46]

In May 1943, it was also decided to move the planned large production 500 metric tons monthly of the nerve gas sarin to Falkenhagen as well. Construction for that facility began in September 1943[47]; completion was planned for April or Mai 1945.[48] In early February 1945, the Falkenhagen factory was cleared out, because the front was moving closer, so the sarin facility was neither completed nor put into operation.

4.1 *Brief Description of the Facilities at the Factory*

The area surveyed for the "Seewerk" Falkenhagen was about nine square kilometers in size, of which just 8.24 km^2 had been transferred to Montan in the land register on April 31, 1944.[49] Originally, the area of the "Gut Falkenhagen" property had been 7.35 km^2.[50] That area included a site intended for a research institute on the former grounds of the Falkenhagen Castle. Montan had acquired, or intended to acquire, another 23.51 km^2 in the Falkenhagen area, so that in the end it would have more than 31.75 km^2.

In July 1943, the "Gesamtplanung Seewerk" (Overall Plan for the Lake Factory) included 5 groups of buildings (A–E), of which only Building Group D, the N-Stoff plant, was built at that time. These groups were to serve the following purposes[51]:

- (A) General operations: Briesen train station, energy distribution, storage for raw materials, administration, main workshops (including transportation workshops), housing for factory security guards, cafeteria for the entire staff, and central kitchen to distribute food to the satellite kitchens.
- (B) Five scientific institutes with semitechnical testing facilities (by the lake).
- (C) Experimental field with "Sprenggarten" (detonation area) and shooting range.
- (D) N-Stoff plant.
- (E) Unknown, presumably later (S) for sarin.

[46]Klenck, Jürgen E. von, "History of the 'Seewerk' (Falkenhagen)," March 26, 1945, p. 3/71, The National Archives, London, WO 208/2186.

[47]Ibid., p. 1/69.

[48]"Die Deutsche Kampfstoff-Produktion," Ludwigshafen am Rhein, February 1, 1944, p.7, BArch R3/1894.

[49]Entwurf eines Schreibens der Montan über Grunderwerb Falkenhagen, June 23. 1944, Preuss private collection.

[50]Anhang zum Bericht der Deutschen Revisions- und Treuhand-Aktiengesellschaft Berlin über die bei der Verwertungsgesellschaft für Montanindustrie GmbH, Berlin-Charlottenburg, vorgenommene Sonderprüfung betr. Forstabteilung, p. 17, BArch Berlin, R 8135/4782.

[51]Baustelle Seewerk: Sachdarstellung über die Gesamtplanung, das Abrechnungswesen, das Sozialwesen, den Werkschutz, Werkfeuerwehr und Werkluftschutz, July 15, 1943, The National Archives, London, FO 1031/179.

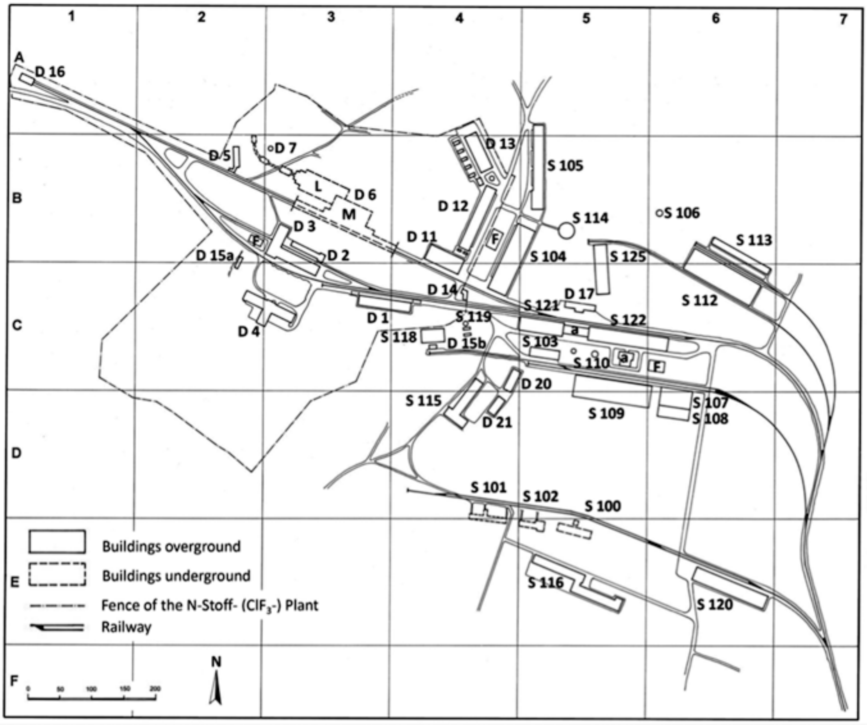

Fig. 3 Layout of Monturon GmbH Falkenhagen ("Seewerk") (Gesamtlageplan - Seewerk S/o (M 1 : 2.500), Dipl. Ing. Max Haaf, Stuttgart, December 21, 1943, Preuss private collection)

In an overall site plan for the Seewerk (Falkenhagen) project of 1943,[52] the buildings of the factory are marked only with the letters D for the N-Stoff plant and S for the sarin plant.

The five scientific institutes (Building Group B) were located on the eastern shore of the Schwarzer See (Black Lake). There were laboratories and a vacuum tunnel to test the ballistic properties of a new type of weapon; these were also referred to as "Institut Ost" (East Institute).[53]

The function of the various buildings could be determined from the lists of buildings on the site plan. The lists of buildings were supplemented by evaluating other written sources (see Fig. 3, Table 7).[54]

[52]Gesamtlageplan–Seewerk S/o (M 1 : 2.500), Dipl. Ing. Max Haaf, Stuttgart, December 21, 1943, Preuss private collection.

[53]Schreiben der Waffenamt-Forschungsabteilung (WaF), Nr. 595/39 gKdos Wa F/A2, an Wa J Rü 10 und Wa J Rü (Mun3) betreffend MO, Büro Prof. Loos. January 30, 1940, Preuss private collection.

[54]Bauvorhaben Seewerk, Zusammenstellung der bis zum 30.06.1943 angefallenen Kosten, The National Archives, London, FO 1031/179.

Table 7 Inventory of buildings: Monturon GmbH Falkenhagen ("Seewerk")

Building-No.	Function	Plant	Coordinates
D 1	Preparation	N-Stoff	C 3/4
D 2	Water purification plant	N-Stoff	B 3
D 3	Workshop, central heating	N-Stoff	B/C 3
D 4	Common room, administration	N-Stoff	C 2/3
D 5	Neutralization	N-Stoff	B 2
D 6	Manufacturing plant L (Tanks)	N-Stoff	B 2/3
D 6	Manufacturing plant M	N-Stoff	B 2/3
D 7	High-level water tank	N-Stoff	B 3
D 8	Workshop	N-Stoff	
D 8a	Workshop	N-Stoff	
D 9	Storehouse	N-Stoff	
D 9a	Storehouse	N-Stoff	
D 10	Defroster	N-Stoff	
D 11	Diesel powerhouse	N-Stoff	B/C 4
D 12	Generator building	N-Stoff	B 4
D 13	Apparatus building	N-Stoff	B 4
D 14	Keeper's lodge	N-Stoff	C 4
D 15a	Purification plant I	N-Stoff	B/C 2
D 15b	Purification plant II	N-Stoff	C 4
D 16	Locomotive shed	N-Stoff	A 1
D 17	Garage	N-Stoff	C 5
D 18	Pump room (lake)		
D 18a	Pump room		
D 20	Laboratory	N-Stoff	C 4
D 21	Laboratory school	N-Stoff	D 4
F	Static water tank		
S 100	Storehouse (underground)	Sarin	E 5
S 101	Storehouse with tanks	Sarin	D/E 4
S 102	Storehouse with tanks	Sarin	E 5
S 103	Storehouse with tanks	Sarin	C 5
S 104	Manufacturing plant	Sarin	B/C 4/5
S 105	Product purification	Sarin	A/B 5
S 106	Chimney	Sarin	B 6
S 107	Boiler house	Sarin	C/D 6
S 108	Turbine house	Sarin	D 6
S 109	Coal yard	Sarin	C/D 5
S 110	Chloromethane gasometer	Sarin	C 5
S 111	Storehouse	Sarin	
S 112	Filling plant	Sarin	B/C 6
S 113	Product purification	Sarin	B/C 6

(continued)

Table 7 (continued)

Building-No.	Function	Plant	Coordinates
S 114	Cooling tower	Sarin	B 5
S 115	Special bath	Sarin	C/D 4
S 116	Casualty ward	Sarin	E 5
S 117	Chimney for acids	Sarin	C 5
S 118	Sewage purification plant	Sarin	C 4
S 119	Sewage purification plant	Sarin	C 4
S 120	Warehouse	Sarin	E 6
S 121	Manufacturing plant	Sarin	C 5
S 121a	Manufacturing plant	Sarin	C 5
S 122	Manufacturing plant	Sarin	C 5/6
S 122a	Manufacturing plant	Sarin	C 5/6
S 123	Mesh net station	Sarin	
S 125	HCl basin	Sarin	B/C 5
S 126	Gas decomposition	Sarin	
S 127	Subway	Sarin	C 4

5 The Development of N-Stoff Production

In 1937 representatives of the Waffenamt visited the laboratories of IG Farbenindustrie AG in Leverkusen. The skin-damaging properties of chlorine trifluoride, and its reactivity when organic and inorganic materials combine with high heat or flame, attracted their interest. Between 1937 and 1944, between three and five metric tons of chlorine trifluoride, which had been produced in a small laboratory-sized plan in Leverkusen, were delivered to the OKH. The Waffenamt saw possible military applications as an incendiary material and later as filling for artillery shells, as propellant for underwater shells and ramjet torpedoes, and as a rocket fuel additive (Schmaltz 2005, 148). Interesting results from experiments with chlorine trifluoride led the research department of the Waffenamt to grant permission as early as 1938 to build a factory for its mass production in Falkenhagen. In addition to the large plant in Falkenhagen, a smaller experimental plant was built under the direction of the OKH on the Kummersdorf testing grounds in Gottow. It was said to have been in operation in 1943.[55]

[55]Enemy Personnel Exploitation Section FIAT, Control Commission for Germany (BE), B.A.O.R. In FIAT EP 254-84 (von Klenck) 14. December 1945, Interrogation Report, pp. 16–19. The National Archives, London, FO 1031/97. Anonymus: Chlortrifluorid (ClF3), Anlage 9(5/-), p. 1p1–19, after 1945, Preuss private collection.

5.1 *The Buildings of the N-Stoff Plant at the "Seewerk" Falkenhagen*

The buildings of the N-Stoff plant are identifiable in Fig. 3 by the initial letter D. They are located in the northwest of the factory grounds inside a fence around the manufacturing plant (D 6). The fenced area is entered via the gate (D 14). Purification plant II (D 15b), a garage (D 17), a laboratory building (D 20), and the laboratory school (D21) were located outside the fence. Located within the fence were, from northeast to southwest, the apparatus building (D 13), the generator building (D 12), the electrical center (D 11), and preparation (D 1). To the west of this last, followed the water purification plant (D 2), the workshop with the central heating, purification plant I (D 15a), and neutralization (D 5). The common building held, among other things, the cafeteria and the rooms for the administration (D 4). Buildings D 8, D 9, D 10, D 18, and D 19 were presumably located outside the area depicted on the factory plan.

6 The Development of the Nerve Gases Tabun and Sarin

In the pest control laboratory of the Elberfeld factory of IG Farbenindustrie AG in 1934 Gerhard Schrader began working on the development of a means to combat aphids. The Heereswaffenamt, to whom this invention was reported in 1935, showed interest. Laboratory experiments on its military usefulness followed in 1936. From 1939, the Wehrmacht conducted experiments with the new chemical weapon on its experimental grounds in Raubkammer, near Munster, and in the army's gas protection laboratory in Berlin-Spandau. The new chemical weapon was assigned the code names tabun, T-83, and G (for Gelan). A plant was built in Dyhernfurth to mass produce it, and from June 1942 to January 1945 a total of 12,753 metric tons of tabun were produced.[56]

In 1938, again in the Elberfeld factory of IG Farbenindustrie AG, Schrader developed another chemical weapon, which after several tests by the Heereswaffenamt was to begin mass production under the name sarin. The code name for sarin was T 46. However, by 1945 just 0.5 metric tons of this chemical warfare agent could be produced in a pilot plant in Raubkammer.[57]

[56]"Die Deutsche Kampfstoff-Produktion, Ludwigshafen am Rhein," February 1, 1944, p. 4, BArch R3/1894. Sonderausschuss C beim Reichsminister für Rüstung und Kriegsproduktion, Bericht über die Lage auf dem Kampfstoffsektor, Auszug aus dem Vortrag im Führerhauptquartier, May 15, 1943, mit einer Gegenüberstellung der Situation vom March 1, 1944, p. 6/32, BArch, R 3/1894. Aufstellung über K-Stoffe, Gesamtfertigung Stand December 1, 1944, p. 67, BArch R3/1894. Sonderausschuß C, Arbeitsbüro Dr. v. Klenck an Dr. Pfaundler, I.G. Frabenindustrie A.G. Produktionszahlen, December 1944, p. 93, BArch R3/1894.

[57]This is an occasion to point out that Eibl (1999, 157 n. 217) wrote that, according to a statement given on the telephone by J. Preuss, some 50 metric tons of N-Stoff and some 500 kg of sarin had been produced in Falkenhagen. This is probably the result of a misunderstanding on the telephone, since the 500 kg of sarin should be credited to Plant R VIII in Munster. Hahn's unsourced

7 The Manufacturing Processes for Sarin

The manufacturing process intended for Falkenhagen was based on the four-step salt method.[58] Mass production of sarin was supposed to reach 500 metric tons monthly in Falkenhagen. A simplified four-step method was planned. The first step was to follow the procedure of IG; the second step could be avoided after a redesign of the chemical processes. The third step was supposed to be produced according to a process developed by the OKH. The production of the final stage—that is, sarin itself—was based on a continuous process that had been tested by the OKH in Building R VIII in Munster. The technical design of the processes and plants was to be in the hands of IG.

On the map of the buildings of the Falkenhagen factory (Fig. 3), the buildings of the sarin plant are identifiable by the initial letter S. In addition to three manufacturing buildings (S 104, S 121, S 122), there are two buildings identified as purification buildings (S 105, S 113); located between the two were a cooling tower (S 114), a chimney (S 106), and a hydrochloric acid basin (S 125). The buildings numbered S 101, S 102, and S 103 had aboveground tanks; there was also an underground storehouse (S 100). There was additional storage in a warehouse (S 120), a chloromethane gasometer (S 110), and a coal yard (S 109). The last of these belonged functionally to the boiler house (S 107) and turbine house (S 108). A separate power plant was planned for the sarin plant. The sewage purification plants (S 118, S 119) would presumably have caused problems when operating the plant, because of the minimal slope. Because a filling plant (S 112) was planned, the dangerous chemical warfare agent sarin was to be filled in bombs and shells at the production facility itself, just like tabun in Dyhernfurth.

In the aerial photograph, another built area with connection to the railroad is identifiable south of the casualty ward (S 116) as well as one between the tank area and the coal yard (S 109). The broad curve of the railroad line is striking and suggests that additional plants were planned on the Falkenhagener Heide.

8 Vereinigte Flussspatgruben GmbH in Stulln

In November 1939 Montan was contracted by the Waffenamt to acquire fluorite mines in the Bavarian districts of Stulln, Lissenthan, and Brudersdorf (near Nabburg). There was particular interest in those owned by the Vereinigte

(Footnote 57 continued)

assertion that sarin production in Falkenhagen had "partially begun," Hahn (1986, 229) is likewise unprovable.

58Aktennotiz der I.G. Farbenindustrie Aktiengesellschaft, Ludwigshafen am Rhein, Zwischenprodukten-Gruppe, betreffend Sarin, July 21, 1943, The National Archives, London, FO 1031/179; Aktennotiz der I.G. Farbenindustrie Aktiengesellschaft, betreffend Sarin, Leverkusen, July 26, 1943, The National Archives, London, FO 1031/179; "Die Lage auf dem K-Stoffgebiet," December 1, 1942, BArch Berlin, R 3112/191.

Flussspatgruben Lissenthan GmbH.[59] Fluorite is the raw material for hydrogen fluoride, which was an intermediate product in N-Stoff production. In the summer of 1942, following a meeting with the head of the central division of the Waffenamt, there was a plan to found a company with headquarters in Falkenhagen for M.O. Falkenhagen that would be merged with Vereinigte Flussspatgruben GmbH, Nabburg, in order to ensure the supply of raw materials for the Falkenhagen factory. The firm Riedel de Haen AG, Berlin was contracted to manage in trust the building of a factory at Flussspatgruben GmbH in Stulln. Hence Riedel de Haen was also asked whether it was prepared to take over as leaseholder the management of the army-owned factory in Falkenhagen.[60]

After the war a team from the British Intelligence Objectives Sub-Committee (BIOS) visited the plant in Stulln. Its report indicates that it was not just a large plant to manufacture hydrofluoric acid and a replacement plant that had been built. The factory in Stulln was so large that it would also have been possible, using the equipment moved from Falkenhagen, to produce chlorine trifluoride (N-Stoff) in a quantity similar to that produced there. Glupe gave the BIOS team a tour of the factory in Stulln; in the text he is referred to as an employee of Riedel de Haen. According to his statements, he had built both the plant in Stulln and the one in Falkenhagen. After he transferred to the Waffen-SS, in October 1944 he had taken on the task of starting N-Stoff production in Falkenhagen for the SS. Glupe had developed the production process for chlorine trifluoride used in Falkenhagen in a laboratory at the Kaiser Wilhelm Institut für physikalische Chemie und Elektrochemie in Berlin. The next step was to build a somewhat larger plant in Gottow. Then Glupe could translate his findings and developments in Falkenhagen and in Stulln on a large technical scale (Schmaltz 2005, 145).[61]

9 The Dyhernfurth Factory of Anorgana GmbH

The site of the factory in Dyhernfurth (now Brzeg Dolny) was between the Oder River and the town of Seifersdorf (now Radecz). The properties were acquired by Montan beginning in 1940. The tabun plant began production in 1942; it was the

[59]Schreiben des Oberkommandos des Heeres (Ch H Rüst u BdE), Wa J Rü Stab IV d an das Oberkommando der Wehrmacht (OKW), W Stab W Rü, betreffend M.-O., Falkenhagen, Erwerb von Flussspatgruben, Antrag auf Bestimmung einer Bedarfsstelle, January 1940, Preuss private collection.

[60]Schreiben des Oberkommandos des Heeres (Ch H Rüst u BdE), 70 o 30 18 Wa J Rü (Mun 3 zbV/VIII), Nr. 10006/43 g.Kdos., an I.D. Riedel - E. de Haen AG, Berlin-Britz betreffend Sonderbauvorhaben OKH, February 18, 1943, Preuss private collection.

[61]BIOS. Final report no. 1595, item no. 22, “German Fluorine and Fluoride Industry,” London, p. 78, Preuss private collection; W. Archer, W. J. V Ward, and O. S. Whitson, “Hydrofluoric Acid, Vereinigte Flusspatgruben GmbH Stulln,” 1946, BIOS target no. C22/2012, C.I.O.S. Black List Item 22, Miscellaneous Chemicals, British Intelligence Objectives Sub-Committee, Preuss private collection.

second-largest producer of a single chemical warfare agent. The operating company of the state-owned Montan plant was Anorgana GmbH, a subsidiary of IG Farbenindustrie AG. The factory's capacity was 1,000 metric tons of tabun monthly in 1944. Altogether, from June 1942 to January 1945, 12,753 metric tons of tabun were produced and filled in bombs and shells.[62] The capacity of the tabun filling plant was 770,000 shells for the light field howitzer (lFH 10.5 cm), or 250,000 shells for the heavy field howitzer (sFH 15 cm), or 12,500 bombs monthly.[63] The map of the factory makes it clear that it was possible to store tabun and the intermediate products for it at the factory. The shells filled with tabun (Green Ring 3) were picked up by the army munitions facilities, which were responsible for chemical weapons, with munitions trains. Consequently, the filled Green Ring 3 bombs were sent to the air munitions institutions for which they were intended. Other chemical warfare agents produced in Dyhernfurth included cyanogen chloride (T 150) beginning in 1943 or 1944, with a capacity of 20 metric tons monthly, and, in addition from 1943 or 1944 hydrogen cyanide (T 155) as well, with a capacity of 20 metric tons monthly, and Bi IV 99 (T 300), an alloy of arsenic, magnesium, and aluminum produced by wetting arsine. The planned capacity of T 300 production was 100 metric tons monthly.[64] An experimental station for filling bombs with chemical warfare agents (e.g., Aeroform) in powder form was built at the end of the war in the HMa St. Georgen (Powder Filling Plant, Building W4 or 1003) (Preuss and Eitelberg 2001,162–65).

10 The Filling and Storage of Chemical Weapons in the Munitions Facilities of the Army and Air Force

With the exceptions of phosgene and tabun, chemical weapons were filled in five army and two air force munitions facilities. The bomb-filling plant in the Ammendorf factory was another exception, but it was active only until the Lufthauptmunitionsanstalt (LHMa; Main Airforce Munitions Facility) in Mockrehna, east of Leipzig, could be put into operation.

[62]List of K-Stoffe, total production as of December 1, 1944, p. 67. R3/1894; Report on the production of C-Stoffe, December 1944, p. 86, R3/1894.

[63]Oberkommando des Heeres (Ch.H.Rüst u. BdE.) Firma IG Farbenindustrie A.G. to the attention of the director, Dr. Ambros o.V. Ludwigshafen am Rhein, concerning the construction contract to build a factory to manufacture Product G, contract no. 9/IXa-240-9018/39, p. 1, The National Archives, London, FO 1031/223.

[64]E. Ehmann, U.S. Army Chemical Warfare Project, A.4, "Produktionsstätten und Produktionshöhen, a) Kampfstoffe," 1948, pp. 720–40, Preuss private collection; report (no. VI/11302) by the Deutschen Revisions- und Treuhand AG, Berlin, on the audit by Anorgana GmbH, Ludwigshafen a/Rh., Dyhernfurth factory, of the annual report on March 31, 1943, copy no. 1, p. 4, The National Archives, London, FO 1031/165.

There were only seven filling plants for chemical weapons in the former German Reich. The first to be built was the filling plant of the HMa Munster, which can be considered the model for the filling plants of the HMa Löcknitz and the HMa St. Georgen (Traunreut). The third generation of buildings were the filling plants of the HMa Dessau and the HMa Lübbecke, which were considerably smaller. The filling plants planned for the Luftwaffe were the LHMa Mockrehna and the LHMa Oerrel (Dethlingen) (Preuss 2002; Preuss and Eitelberg 2003a, b). These plants were planned and built by Orgacid/Lonal.

11 The Chemical Weapons Complex in Munster

The chemical weapons complex in Munster was located within the Truppenübungsplatz Munster (Munster military training area), the history of which will be sketched below based on a Festschrift produced 1983 by the Kampftruppenschule 2.[65]

The moor, forest, and heath areas to the south and southwest of Munster, a small village on the around 40 km north of Celle on the Lüneburger Heide, were expanded from 1892 onward into a military training area of circa 49 km^2. The first troops arrived on June 7, 1893. There they found around fifty newly constructed buildings, and that number grew over the next two decades until the beginning of the First World War to more than 144 buildings. In January 1916, construction began on another training area north of Munster, around Breloh and along the railroad line to Uelzen, in the forest area of Raubkammer. It was referred to as Munster-Nord (Munster-North) to distinguish it. Within this area, between the Heidkrug outwork to the east, Breloh to the west, and north of the railroad line to Uelzen, the Gasplatz Breloh (Breloh gas area), of around 4.4 km^2, was built in 1917. It served as a filling plant for gas shells. In addition, field experiments with the use of chemical warfare agents were carried out in Munster-Nord. The Clark factory served to fill Blaukreuz munition. Grünkreuz (Green Cross) shells were produced in the Klopper factory, and Gelbkreuz (Yellow Cross) shells in the Lostwerk. The filling plants were headed by Dr. Hugo Stoltzenberg, who had also played a role in Munster after the First World War and in the secret rearmament between the wars (Stoltzenberg 1994, 333–34).

At the end of the First World War, the Gasplatz Breloh had around 48,000 metric tons of gas munitions and several thousand tons of seized munitions as well as 100 tank cars and containers with liquid chemical warfare agents.[66]

Of these, around a million chemical warfare shells and 230,000 chemical warfare mines as well as 40 tank cars and containers with chemical warfare agents were

[65]Spezialstab ATV, Gruppe Ausbildungsmaterial, Kampftruppenschule 2, *90 Jahre Truppenübungsplatz Munster, 1893–1983* (Munster 1983).

[66]Ibid., p. 24.

exploded on October 24, 1919. In addition, 42 buildings of the Grünkreuzwerk and the Gelbkreuzwerk were destroyed. Around 950 metric tons of chemical warfare agents in liquid and solid form, which had been stored in approximately 60 tank cars, survived. The glass bottles filled with 500–1000 metric tons of Blaukreuz that had been uncovered when the munitions were dismantled were stored in Munster-Nord at this time. Because the remaining 60 tank cars were needed for other purposes, they were supposed to be emptied as quickly as possible. Hugo Stoltzenberg received instructions from the Reichstreuhandgesellschaft (Reich Trust Company) to destroy the chemical weapons. Previously, in a meeting between the Ministry of Finance, the Kaiser-Wilhelm-Institut für physikalische Chemie und Elektrochemie (Fritz Haber), the Ministries of Trade, Commerce, Transportation, and Labor, as well as the Reichstreuhandgesellschaft on October 28, 1920, there had been negotiations about how Stoltzenberg should destroy the chemical weapons. In the meeting, Privy Councilor Mente had described Dr. Stoltzenberg as very trustworthy. Haber explained that Stoltzenberg had worked under his direction and that he could give him the best recommendation. In a meeting on December 17, 1920, it was revealed that Stoltzenberg had been director of the filling plant in Breloh during the war. In the meeting on October 28, 1920, the representative of the Reichstreuhandgesellschaft explained that it was estimated that 1,000 metric tons of gas artillery shells and cylinders (filled with Blaukreuz) were scattered about the German Reich. "In total, there ca. 2,000,000 such shells in around 35 locations. Of those 500–600,000 were stored in Unterlüss."[67] It is largely unknown what happened with those shells. Hence the discussions that follow are still significant today. There are three types of sites for burying gas shells and cylinders filled with Blaukreuz, in which they have also demonstrably been found.

First, factories in which, during the First World War, chemical warfare agents had been produced and filled in glass bottles, metal containers or shells, and the filling plants in which glass bottles and metal containers filled with Blaukreuz were inserted into empty shells and covered with explosives (15 sites). Examples: At the former chemical factory of E.-Schering AG in Berlin, several thousand 10-centimeter Gelbkreuz shells from the First World War were buried in three pits after the Second World War. In Wahn, near Cologne, in 1976, 1064 drums of 200 L each were filled with Clark bottles from the First World War and brought to the mine in Herfa-Neurode. Secondly, it is to be expected that agents and munitions were buried at former dismantling sites as well, where, according to existing files, more than 25,000 gas shells were present (31 sites).[68] Example: In Hallschlag, after

[67]Besprechung im Reichsschatzministerium III betr. Gasplatz Breloh, unter Vorsitz des Herrn Ministerialdirektors Kautz, October 28, 1920, BArch R 2201/3305; HQ-ETO-US-Army CWS, War Office, "Intelligence Division Report, no. 3961" Report on German CW Dump at Münster-Ost" (= Munster), June 23, 1945, National Archives, Washington, DC., RG 338; Bericht über die Vernichtung von Gas-Kampfstoffen, Berlin, December 17, 1920, BArch, R 2201/3305.

[68]Reichsschatzministerium, Listen der Orte, an denen Zerlegungsarbeiten von Munition vorgenommen wurden oder wo dies beabsichtigt ist, 1. Zerlegestelle für Eisenmunition und Metallkartuschen (1919–22), BArch 2201-Nr. 3225.

the First World War, some 950,000 shells were dismantled, of which around 1.3% were filled with chemical warfare agents. Most of them were destroyed in Hallschlag as well. Intense research in the 1990s was able to identify another circa 500 shells from the First World War.

Thirdly, chemical warfare agents have also been found at sites where they were supposed to be used for commercial purposes after the First World War. For example, Monzingen, near Bad Kreuznach, where 8,000 glass bottles filled with Blaukreuz and 30,000 7.5-cm shells filled with phosgene had been buried and were uncovered after the Second World War. The Stolzenberg factory in Hamburg is another example.

Even after the explosion in Munster, additional chemical munitions were brought to Munster from dismantling sites in the 1920s to be dismantled or exploded as part of contracts between the Reichsschatzamt and Evaporator AG. It is not known whether all 35 dismantling sites delivered shells with chemical munitions and filled glass bottles to Evaporator AG. It is, however, known that shells and/or glass bottles with chemical warfare agents were buried at some of these sites.

From 1934–35, the Munster-Nord exercise area was reconverted into a testing ground for chemical warfare agents and from 1939 onward expanded to 108 km^2.[69]

On April 17, 1945, Munster was occupied by British troops, who found several large facilities for chemical warfare agents in its forests. These included the Raubkammer military exercise area with the Raubkammer army experimental site and the Munster-Nord filling plant as well as the air force testing site of Munster-Nord, the HMa Munster-Ost, the LHMa Örrel, and various facilities of the Nebeltruppen (smoke-mortar troops). To the surprise of the British, however, there were also employees and documents from the Heereswaffenamt and the army's gas-protection laboratory in Berlin-Spandau found in Munster, where they had been moved to protect them from bombing and the approaching Soviet troops.[70]

Directly north of Munster, the British discovered the Munster-Raubkammer (Munster-Nord) military exercise area, which was around 16 km long and 8 km wide and covered with pines and heather. Roughly in its center was a large testing ground for chemical artillery and to the east of that a place to drop chemical bombs. The Heeresversuchsstelle Raubkammer (Raubkammer Army Testing Grounds), including several buildings, was located in the southwest part of Munster-Nord. It was subdivided into *Bereiche* (areas), which were numbered from R I to R IX, not including the administration. Bereich R I was responsible for field testing and photographic documentation. Bereich R II had the chemistry laboratory. Bereich R III consisted of several buildings for decontamination, gas detection, and the maintenance and repair of

[69]Spezialstab ATV, Gruppe Ausbildungsmaterial, Kampftruppenschule 2, *90 Jahre* Truppenübungsplatz *Munster, 1893–1983* (Munster 1983), pp. 33, 54.

[70]"Report on the C. W. Experimental Station at Raubkammer bei Munster and related Establishments," 1945, C.D.R-5. Enemy C. W. and Smoke Intelligence Summary, no. 83, The National Archives, London, WO 208/3576; A. K. Mills, "Investigation of Chemical Warfare Installations in the Munsterlager Area, including Raubkammer," 1945, report no. XXXI-86, CIOS Item 8, Chemical Warfare, Combined Intelligence Objectives Sub-Committee (CIOS), G-2 Division, SHAEF (Rear) APO 413, Preuss private collection.

protective clothing. Bereich R IV had parking garages and an auto repair shop. In Bereich R V, medical aspects of the field tests and toxicology were studied, and R VII was the medical area. East of this complex of related buildings was Bereich R VI, which measured around 600 by 400 meters and was an experimental plant for the production of chemical munitions, with equipment to melt and mold chemical agents and to manufacture munitions. In addition, experiments with hot and cold storage were conducted in this area, and munitions and chemical agents could be stored in six munitions buildings and six warehouses respectively. East of that, between R VI and R VIII, was the Nebelfüllstelle (Smoke Filling Plant) Munster-Nord. The *Nebel* (smoke) was replacing the term *Kampfstoff* (chemical warfare agent). Initially, it was used for testing filling methods for chemical warfare agents. Increasingly, however, the plant was used for ordinary filling work. In addition to the Nebelfüllstelle in Munster, there were chemical filling plants for the army in St. Georgen, Löcknitz, Dessau, and Lübbecke. The plant at Lübbecke, however, was partially functional, but was never in operation (Preuss und Eitelberg 2003a, 164). The air force also had a filling plant in Mockrehna and one in Örrel. The Nebelfüllstelle in Munster had around 60 buildings. The central plant was the bunker for chemical agents, with eight tanks holding 450 cubic meters of chemical agents each (a maximum of ca. 4700 metric tons) and two filling buildings. Füllhaus I had two automatic filling machines for shells, below which were twelve tanks for intermediate storage of mustard gas and arsine oil. In Füllhaus II stood two semiautomatic filling machines for 15-cm rockets and four semiautomatic machines for shells. Three buildings were available for preparing and finishing munitions.

The testing site for the air force was immediately adjacent. This post consisted of five small and one medium-sized two-story buildings. Their task was to develop additional ways for the air force to employ chemical warfare agents. In addition to a laboratory and rooms for filling and testing bombs, spraying and molding equipment for liquid chemical agents was studied and tested. Outside the buildings, the British found 250-kg bombs marked with three green rings. They claimed they had contained sarin that had been destroyed shortly before the Allies arrived. In fact, however, the three green rings indicated they were filled with tabun (Preuss and Eitelberg 2003a, 414). Sarin would have been marked with five green rings. A little farther to the east followed Bereiche R VIII (Vorwerk Heidkrug), which was camouflaged to look like a farm. For a time, tabun, excelsior (10 metric tons), and sarin (0.5 metric tons) were produced there in small quantities in succession. Bereich R IX housed animals and facilities for animal experiments. On the grounds of Munster-Nord, there were more than ten areas for testing and experimenting the use of chemical munitions and decontaminants.

Southeast of Munster was the LHMa Örrel. The British found 131,000 bombs of various sizes there, stored in bunkers. There was also a mustard gas filling plant for 250 and 500 kg bombs with two semiautomatic filling machines and one destroyed mobile filling plant for mustard gas, mounted on a railroad car; additional mobile filling plants were said to have been stationed in St. Georgen and Löcknitz.[71]

[71]A.K. Mills, “Investigation of Chemical Warfare Installations in the Munsterlager Area, including Raubkammer,” report no. XXXI-86, CIOS Item 8, Chemical Warfare, Combined Intelligence

The Heeresmunitionsanstalt Munster-Ost was located about two kilometers southwest of Munster. It had around 17,000 metric tons of chemical munitions in the form of 763,580 filled gas shells and rockets and 7000 bombs.[72]

In November 1945 quantities of unfilled mustard gas in Munster were burned in a continuous process in an open trough. It was located 20–25 m from the mustard gas bunker of the Nebelfüllstelle. It was determined that arsenic compounds could be burned together with it. In addition, the contents of a large number of Italian one- and two-ton mustard gas containers were burned. They were stored outdoors and in warehouses. The incineration of chemical warfare agents was proposed by the British as a way of destroying chemical agents in the American zone as well. They were so convinced of this method that they also used it for British chemical warfare agents (mustard gas, lewisite) in the Bowes Moor munitions depot of the R.A.F.[73]

After the war, the heavy contamination of many areas prevented the use of the Truppenübungsplatz Munster-Nord for military training purposes. For that reason, efforts to study and decontaminate the grounds began in 1950. At first, the areas cleared for use were used only by British troops for exercises. In 1954, the Bundeswehr took over the grounds, and so from May 1956 German soldiers were trained there as well. At the same time, the Entgiftungskommando Raubkammer (Raubkammer Decontamination Command) was working on removing chemical traces from two world wars. The pressure on the Entgiftungskommando was great, because there was a lack of training areas at the time. That led to chemical munitions that had already been removed being transported to another site to be dismantled. In Munster, by April 1960, after thirty-eight months, 38 km^2 of contaminated grounds had been scoured by 60–70 employees, removing circa 48,000 shells, bombs, and containers for chemical warfare agents.[74] Even after that, however, parts of the site were considered unsafe, so that a small group continued to remove munitions from the First and Second World War from the military training area.

On September 6, 1979, these specialists had an opportunity to be active in the civilian realm as well, when a child playing near the former site of the Chemische Fabrik Dr. Hugo Stoltzenberg in Hamburg was fatally injured. The Bundeswehr bomb disposal group from Munster was brought into investigate the grounds. It found circa 100 metric tons of munitions and chemicals on the abandoned industrial

(Footnote 71 continued)

Objectives Sub-Committee (CIOS), G-2 Division, SHAEF (Rear) APO 413, Preuss private collection.

[72]HQ-ETO-US-Army CWS, The War Office: Intelligence Division Report No. 3961, Report on German CW Dump at Münster-Ost (= Munster), June 23, 1945. National Archives, Washington, DC, RG 338.

[73]Williams, C., Burning of Mustard Gas and Lewisite at N0. 81 M.U., R.A.F., Bowes Moor, Estimation of Risk. Summary of Porton Report No. 2744. 1947. National Archives, Washington, DC., RG 338.

[74]Spezialstab ATV, Gruppe Ausbildungsmaterial, Kampftruppenschule 2, *90 Jahre Truppenübungsplatz Munster, 1893–1983* (Munster 1983), pp. 49–50.

site (Scholz 2004). Dr. Hugo Stoltzenberg had attracted attention previously, because in 1928 a phosgene cloud was emitted from a tank car on his factory grounds that injured and even killed people.[75]

The Stoltzenberg factory drew attention again when the British visited it on June 21, 1945, and found dangerous chemicals, hand grenades filled with Blaukreuz and Weisskreuz, as well as smoke candles, incendiary materials, chemical warfare agents for training purposes, and 100 one-liter bottles with chloropicrin (PS). After his work in Breloh during and after the First World War, Stoltzenberg, probably on the recommendation of Fritz Haber, worked as a specialist in chemical warfare agents and munitions in a chemical factory in Hamburg and built chemical plants in Russia, Yugoslavia, Brazil, and Spain and hence participated in secret projects of the Reichswehr.[76]

The removal of munitions from the First and Second World War in Breloh continued in the 1980s. A first incineration plant was built for the destruction of chemical warfare agents. The second plant, which met all the requirements of the authorities, was operated by a federal organization: the Gesellschaft zur Entsorgung von chemischen Kampfstoffen und Rüstungsaltlasten mbH (GEKA mbH); (limited company for the removal of chemical warfare agents and armaments waste). With its 150 employees, it is capable of incinerating shells up to a caliber of 15 cm without dismantling them. It has facilities to clean contaminated soil, a plasma plant, a detonation chamber, and facilities to dismantle munitions. In terms of its construction, the facility is pioneering, and it also deals with munitions and excavated soil from other former munitions locations in Germany and abroad.

12 Other Munitions Sites with Filling Plants for Chemical Weapons

After the war and during the initial phase of the Allied occupation, large quantities of munitions were located in sites for chemical weapons that had filling plants. In the HMa Lübbecke, from April to August 1945, a total of 530,000 shells and mines with chemical warfare agents were stored, 117,000 of which were from Italy (Preuss and Eitelberg 2003b, 351). In the HMa St. Georgen, as a result of the United States Army's collection actions, 1,655,000 chemical shells and mines were

[75]"Note de la Delegation Française au sujet de l'explosion de gaz phosgens à Hambourg," June 14, 1928, "Notes d'un Secretair prises au cours d'un réunion tenne au Quai d'Orsay le lundi, December 3, 1928, Service historique de la Défense, Vincennes, 4N91 Dossier 1 Conférence des Ambassadeurs.

[76]Chemische Fabrik Dr. Hugo Stoltzenberg, Hamburg, Germany, Intelligence Division Report No. 3953, CIOS, Headquarters European Theater of Operations United States Army Chemical Warfare Service. National Archives, Washington, DC, RG 338.

stored, along with 5870 metric tons of unfilled German chemical agents and 1600 m^3 (ca. 2100 metric tons) Italian and Hungarian chemical agents in drums (Preuss and Eitelberg 2001, 204, 216).

The enormous quantity of Germany munitions but also the battlefield munitions of the Allies were dismantled or exploded in Germany. Large quantities were sunk at sea by order of the Allies (Frondorf 1993).[77]

13 Dismantling Work After the First World War

All of the dismantling work after the First World War was done under contracts between either states or the occupying armies and private companies. One example of this is the former factory of Espagit AG in Hallschlag, where 992,000 shells were dismantled after the First World War, 23,800 of which were gas shells. This factory was also ultimately destroyed by a large explosion (Preuss and Eitelberg 1999) It took years to collection the munitions that had been scattered by explosions. The project of studying the site in Hallschlag and making it safe cost around 50 million euros in the 1990s.

14 Summary and Prospects

The production of the chemical weapons industry and the processing and storage of its products cost many human lives and hundreds of millions of reichsmarks by the end of the Second World War. Even today, considerable funds have to be spent removing old munitions and waste left over from the production of chemical armaments in the First and Second World Wars from the soils and groundwater. The front lines—of the First World War, for example—were never thoroughly cleaned up because the project seemed hopeless; instead, in large areas only superficial cleanup was done. However, initial steps in this direction can be observed (Hubé 2016). The areas affected in that period are in Belgium, France, Italy, and Poland. The "Zone Rouge" identified in France after the First World War measured around 10,000 km^2. Even today, it is largely reserved for forestry.

After a century, isn't it time to set ourselves the task of removing the remains of the two world wars in European solidarity using modern concepts and methods?

[77]See also: The History of Captured Enemy Toxic Munitions in the American Zone, European Theater, May 1945 to June 1947, Section VI Operation Davey Jones Locker, Chemical Corps 1946. Office of the Chief of Chemical Corps, Headquarters European Command, Preuss private collection.

References and Source Materials

Aktennotiz der IG Farbenindustrie Aktiengesellschaft, betreffend Sarin, Leverkusen, July 26, 1943. The National Archives, London, FO 1031/179.

Aktennotiz der IG Farbenindustrie Aktiengesellschaft, Ludwigshafen am Rhein, Zwischenprodukten-Gruppe, betreffend Sarin. July 21, 1943. The National Archives, London, FO 1031/179.

Aktennotiz des Wa J Rü (Mun), Az. 70 o 40-19 Wa J Rü/Mun 3 zbV/IX, Nr. 1320/43 g.Kdos. betreffend die Ausweichstelle des Reichsamtes für Wirtschaftsausbau in Falkenhagen. July 26, 1943. Private Collection Preuss.

Aktenvermerk (Nr. 8) der IVG betreffend nach Stulln verlagertes Gut aus Falkenhagen. May 23, 1952. Private Collection Preuss.

Aktenvermerk der Montan betreffend Seewerk. July 25, 1944. Private Collection Preuss.

Anhang zum Bericht der Deutschen Revisions- und Treuhand-Aktiengesellschaft Berlin über die bei der Verwertungsgesellschaft für Montanindustrie GmbH, Berlin-Charlottenburg, vorgenommene Sonderprüfung betr. Forstabteilung, BArch Berlin, R 8125/1691.

Anonymus, Chlortrifluorid (ClF3), Anlage 9(5/-), p. 9–11, post 1945. Private Collection Preuss.

Arbeitsberichte Chemie Werk Kapen, Seite 1247 (April 17, 1957), 1249 (February 11, 1957), 1722 (February 2, 1957) sowie Zusammenfassungen von Berichten zwischen dem January 29, 1953 und dem July 23, 1956, Private Collection Preuss.

Archer, W., W.J.V. Ward and O.S. Whitson, Hydrofluric Acid, Vereinigte Flusspatgruben G.m.b. H. Stulln. 1946. BIOS Target No. C22/2012, C.I.O.S. Black List Item 22, Miscellaneous Chemicals, British Intelligence Objectives Sub-Committee. Private Collection Preuss.

BIOS. Final Report No. 1595, Item No. 22, Carter, W. J., M. A. Howick, J. R. Burston, R. Y. Eagers and A. B. Crooks, German Fluorine and Fluoride Industry, London 1945, Private Collection Preuss.

Bausinger, Tobias. 2007. *Ausbreitung von Nitroaromaten über das Sickerwasser der ehemaligen Espagit AG in Hallschlag. Ein Beitrag zur geoökologischen Bewertung eines kontaminierten Standortes*. PhD dissertation, University of Mainz.

Bausinger, Tobias, Ulrich Dehner, and Johannes Preuss. 2005. Nitrodiphenylaminen und verwandten Verbindungen im Sickerwasser einer Rüstungsaltlast. *Umweltwissenschaften und Schadstoff-Forschung* 17 (1): 7–12.

Baustelle Seewerk: Sachdarstellung über die Gesamtplanung, das Abrechnungswesen, das Sozialwesen, den Werkschutz, Werkfeuerwehr und Werkluftschutz. July 15, 1943. The National Archives, London, FO 1031/179.

Bauvorhaben Seewerk, Zusammenstellung der bis zum 30.06,1943 angefallenen Kosten. The National Archives, London, FO 1031/179.

Bericht über die Deutsche Kampfstoff-Produktion. February 1, 1944. BArch Berlin, R3/1894.

Bericht über die Lage auf dem K-Stoffgebiet. December 1, 1942. BArch R 3112/191.

Bericht über die Vernichtung von Gas-Kampfstoffen, Berlin, December 17, 1920. Bundesarchiv, BArch Berlin, R 2201/3305.

Besprechung im Reichsschatzministerium III betr. Gasplatz Breloh, unter Vorsitz des Herrn Ministerialdirektors Kautz. October 28, 1920. Bundesarchiv, BArch R 2201/3305.

Boyne, J.G., E.W. Lanfear, W.S. Calcott, and P.J. Leaper. 1945. Production of Vesicant Agents at Ammendorf. M52.D92., CIOS Target No. 8/30 Chemical Warfare, Item No. 8, File No XXXII-7, Combined Intelligence Objektives Sub-Committee G-2 Division, SHAEF (Rear) APO 413, National Archives, Washington, RG 338 and British Library, Document Supply Center, Boston Spa.

Brauch, Hans Günter, and Rolf-Dieter Müller (eds.). 1985. *Chemische Kriegführung. Chemische Abrüstung. Dokumente und Kommentare*. Berlin: Berlin Verlag Arno Spitz.

Bundesarchive Koblenz und Freiburg. 1979. Fertigung, Lagerung und Beseitigung chemischer Kampfstoffe unter besonderer Berücksichtigung des Territoriums der Bundesrepublik Deutschland. BArch Koblenz, 35 pages. Private Collection Preuss.

Burning of Bulk Mustard, Raubkammer, Germany, HQ-ETO (REAR) CWS-APO No. 887 to Chief CW Officer. November 6, 1945. National Archives, Washington, DC., RG 338.

Chemische Fabrik –Dr. Hugo Stoltzenberg, Hamburg, Germany, Intelligence Division Report No. 3953, CIOS, Headquarters European Theater of Operations United States Army Chemical Warfare Service. June 21, 1945. National Archives, Washington, DC., RG 338.

Der deutsch-französische Krieg 1870–71. 1881. Redigiert von der kriegsgeschichtlichen Abteilung des großen Generalstabes. Zweiter Teil. *Geschichte des Krieges gegen die Republik*. Dritter Band, des Gesamtwerkes V. Band. Berlin: Mittler.

Ehmann, Emil. 1948. U.S. Army Chemical Warfare Project, A.4. Produktionsstätten und Produktionshöhen, a) Kampfstoffe, 720–740. Private Collection Preuss.

Eibl, Christina. 1999. *Der Physikochemiker Peter Adolf Thiessen als Wissenschaftsorganisator (1899–1990). Eine biographische Studie*. Diss. phil. Dreieich: Historical Institute of the University of Stuttgart, Abteilung für Geschichte der Naturwissenschaften und Technik.

Entwürfe der Schreiben von Wa B 4 VII an die Orgacid GmbH, Vorbescheide zur Errichtung von Anlage, December 10, 1934. National Archive, London, FO 1031/204.

Frondorf, Mark J. 1993. Special Study on the Sea Disposal of Chemical Munitions. Science Applicatios International Corporation, Sponsored by U.S. Arms Control and Disarmament Agency, Contract Number: AC92RC1005, Task Order: 92-01, Mclean, Virginia.

Gesamtlageplan—Seewerk S/O (M 1: 2,500). December 21, 1943. Private Collection Preuss.

Gesellschaftsvertrag: Urkunde Nr. 331/1934, Notar Dr. F. Jacke. November 23, 1934. Private Collection Preuss.

Griess, T.E. (ed.). 1985. *Atlas for the Second World War, Europe and the Mediterranean*. Wayne: Avery Publishing Group.

Gutachten Nr 48. Entwurf eines Bau- und Errichtungsauftrages für die Errichtung der Sarin II Anlage in Seewerk (Auftrags-Nr. 3/IX-4888-9026/43), ohne Datum. The National Archives, London, FO 1031/179.

Hahn, Friedrich. 1986. *Waffen und Geheimwaffen des Deutschen Heeres 1933–1945*. Band 1: *Infanteriewaffen, Pionierwaffen, Artilleriewaffen, Pulver, Spreng- und Kampfstoffe*. Koblenz: Bernhard & Graefe Verlag.

HQ-ETO-US-Army CWS, The War Office: Intelligence Division Report No. 3961, Report on German CW Dump at Münster-Ost (= Munster-Ost), June 23, 1945. National Archives, Washington, DC. RG 338.

Hubé, Daniel. 2016. *Sur les traces d´un secret enfoui-Enquete sur l´heritage toxique de la Grande Guerre. Préface de Jean-Yves Le Naour*. Paris: Michalon Éditeur.

Klenck, Jürgen E. von. 1945. History of the 'Seewerk' (Falkenhagen), The National Archives, London, WO 208/2186.

König, Wolfram and Ulrich Schneider. 1985. *Sprengstoff aus Hirschhagen. Vergangenheit und Gegenwart einer Munitionsfabrik. Nationalsozialismus in Nordhessen*, Bd. 8. Kassel: Verlag Gesamthochschulbibliothek Kassel.

Lebenslauf Max Zeidelhack. March 27, 1948. Bayerisches Hauptstaatsarchiv München, Office of Military Government, Bavaria, 13/83-2/5, National Archives, Microfilm Publication 12065 Section 3-402/NNDG No. 775037).

Lebenslauf von Prof. Dr. H. Engelhard, February 15, 1960, Universitätsarchiv Göttingen, UAG-Kur. 10221.

Mense-Stefan, Anne. 2005. *Standortdifferenzierte Abschätzung von Sickerwasserraten in Hessen. Ein Beitrag zur Ermittlung von Stofffrachten aus dem Boden*. PhD diss. University of Mainz, Mainzer Geographische Studien, Bd. 53.

Mills, A.K., Investigation of Chemical Warfare Installations in the Munsterlager Area, including Raubkammer. 1945. Report No. XXXI-86, CIOS Item 8, Chemical Warfare, Combined Intelligence Objektives Sub-Committee (CIOS), G-2 Division, SHAEF (Rear) APO 413, Private Collection Preuss.

Monturon GmbH, Aufstellung des Buchwertes zum 31.03,1944 (= Anschaffungswert 1944), Werk Falkenhagen. Private Collection Preuss.

Monturon GmbH. Abschlussbericht 1943/1944, Fabrikhauptbuch Seewerk. Private Collection Preuss.

Note de la Delegation Francaise au sujet de l´explosion de gaz phosgens à Hambourg. June 14, 1928. Notes d´un Secretair prises au cours d´un réunion tenne au Quai d´Orsay le lundi 3. Dez. 1928. Service historique de la Défense, Vincennes, 4N91 Dossier 1 Conférence des Ambassadeurs.

Note de la Delegation Francaise au sujet de l´explosion de gaz phosgens à Hambourg. June 14, 1928. Notes d´un Secretair prises au cours d´un réunion tenne au Quai d´Orsay le lundi 3. Dez. 1928. Service historique de la Défense, Vincennes, 4N91 Dossier 1 Conférence des Ambassadeurs.Orgacid GmbH. Bericht über das Geschäftsjahr 1937/38. December 21, 1938. Private Collection Preuss.

Oberkommando des Heeres (Ch.H.Rüst u. BdE.) Firma IG Farbenindustrie A.G. to the attention of the director, Dr. Ambros o.V. Ludwigshafen am Rhein, concerning the construction contract to build a factory to manufacture Product G, contract no. 9/IXa-240-9018/39, p. 1, The National Archives, London, FO 1031/223.

Orgacid GmbH. Bericht über das Geschäftsjahr 1938/39. December 21, 1939. Private Collection Preuss.

Orgacid GmbH. Bericht über das Geschäftsjahr 1939/40. 1939. Private Collection Preuss.

Orgacid GmbH. Vorläufiger Geschäftsbericht über das Geschäftsjahr 1940/41. From April 1, 1941 to December 31 1940. Private Collection Preuss.

Orgacid GmbH. Vorläufiger Geschäftsbericht über das Geschäftsjahr 1941/42. From April 1, 1941 to December 31 1941. Private Collection Preuss.

Orgacid GmbH, Bericht über das Geschäftsjahr 1943–44. Private Collection Preuss.

Preuss, Johannes. 1990. *Vorerkundungen und Bewertungen des Gefährdungspotenzials altlastenverdächtiger Betriebsflächen der ehemaligen Rüstungsindustrie – Stadtallendorf, Landkreis Marburg, Biedenkopf*. Postdoctoral thesis, University of Marburg, unpublished.

Preuss, Johannes. 2002. *Zahlencode-System des Heeres von 1925 bis 1940*. Schwäbisch-Hall: Journal Verlag Schwend.

Preuss, Johannes, Ulrich Dehner and Frank Eitelberg, et al. 1994. Erkundung und Rekonstruktion des ehemaligen Werkes der Deutschen Sprengchemie (DSC) Werk Kraiburg, (unpublished for Stadtverwaltung Waldkraiburg).

Preuss, Johannes und Frank Eitelberg. 1994. *Rekonstruktion der ehemaligen Fabrik zur Herstellung von Brand- und Kampfstoff: N-Stoff und Sarin der Monturon GmbH in Falkenhagen*. Mainz: Johannes-Gutenberg-Universität Mainz, Geographisches Institut, (unpublished for Landesbauamt Frankfut/Oder).

Preuss, Johannes und Frank Eitelberg. 1996. *Ehemalige Anlagen und Produktionsverfahren auf Rüstungsaltstandorten und ihre Bewertung. Handbuch Altlasten*, Bd. 4 Wiesbaden: HLUG.

Preuss, Johannes und Frank Eitelberg. 1999. *Hallschlag. Historisch-genetische Studie zur ehemaligen Fabrik für die Herstellung von Trinitrotoluol, Dinitrobenzol und Presskörpern aus Sprengstoffen sowie zur Verfüllung und Entlaborierung von Munition der ESPAGIT AG. Mainzer Geographische Studien*, Bd. 45. Mainz: Johannes-Gutenberg-Universität Mainz, Geographisches Institut.

Preuss, Johannes und Frank Eitelberg. 2001. *Historisch-genetische Studie über die ehemalige Heeres-Munitionsanstalt St. Georgen*, (unpublished for Stadtverwaltung Traunreut).

Preuss, Johannes und Frank Eitelberg. 2003a. *Heeres-Munitionsanstalt Lübbecke. Vorgeschichte der Stadt Espelkamp*. Mainzer Geographische Studien, Sonderband 1. Mainz: Johannes-Gutenberg-Universität Mainz, Geographisches Institut.

Preuss, Johannes und Frank Eitelberg. 2003b. *Vertiefende Historisch-Genetische Studie und Geländebegehung über die ehemalige Kampfstoff-Füllstelle der HMa Dessau* (Kapen), (unpublished for Landesanstalt für Altlastenfreistellung, Magdeburg).

Preuss, Johannes and Frank Eitelberg. 2009. *Das Werk Kraiburg der Deutschen Sprengchemie GmbH 1938–1945. Waldkraiburg schaut zurück. Geschichte einer jungen Stadt*. 2nd rev. ed., Stadt Waldkraiburg.

Preuss, Johannes und Frank Eitelberg. 2010. *Die TEUTO-Metallwerke GmbH in Osnabrück. Rekonstruktion einer Fabrik für Infanteriemunition und Hülsen für Bordwaffenmunition der Jahre 1935–1945. Mainzer Geographische Studien*, Sonderband 6, Mainz: Johannes-Gutenberg-Universität Mainz, Geographisches Institut.

Preuss, Johannes, Frank Eitelberg, Gerd Albrecht, et al. 2002. Modellhafte Altlastenuntersuchung an ausgewählten Standorten der Munitionszerlegung und -vernichtung nach dem Ersten Weltkrieg. *UBA Text* 49(2): 141 pages.

Preuss, Johannes, Frank Eitelberg, and Tania Bader-Nia, et al. 1993. Erkundung und Rekonstruktion des ehemaligen Werkes der Westfälisch Anhaltinischen Sprengstoff AG (WASAG) in Reinsdorf, Lutherstadt Wittenberge, (unpublished for Stadtverwaltung Wittenberg), 2 vols.

Preuss, Johannes, Frank Eitelberg and Wolfgang Form. 1992. Rüstungsaltstandorte und Verdachtsflächen in Hessen (1. und 2. Weltkrieg), (unpublished for Hessisches Ministerium für Umwelt, Reaktorsicherheit und Bundesangelegenheiten).

Preuss, Johannes, Frank Eitelberg and Peter Wilmes. 1992. Rekonstruktion der ehemaligen Rüstungsbetriebe in Geretsried - Deutsche Sprengchemie (DSC) Geretsried und Dynamit Actien Gesellschaft - Gesellschaft zur Verwertung Chemischer Erzeugnisse (DAG/Verwert) Wolfratshausen, (unpublished for Stadtverwaltung Geretsried).

Preuss, Johannes and Ulrich Schneider. 2005. Rüstungsaltlasten in Deutschland. In *Boden gut gemacht. Die Sanierung des Rüstungsaltstandortes Stadtallendorf*, ed. Hessisches Ministerium für Umwelt. Wiesbaden: Hessisches Ministerium für Umwelt, 21–63.

Reichsschatzministerium, Listen der Orte, an denen Zerlegungsarbeiten von Munition vorgenommen wurden oder wo dies beabsichtigt ist, 1. Zerlegestellen für Eisenmunition und Metallkartuschen (1919–1922), BArch 2201/3225.

Reile, Heidrun. 2005. Kosten. In *Boden gut gemacht. Sie Sanierung des Rüstungsstandortes Stadtallendorf*, ed. Hessisches Ministerium für Umwelt. Meckenheim, 419–424.

Report on the C.W. Experimental Station at Raubkammer bei Munster and related Establishments. C.D.R-5. Enemy C.W. and Smoke Intelligence Summary, No. 83, 1945, The National Archives, WO 208/3576.

Rundschreiben der Monturon GmbH, Nr. 914/45/IVa1/Pr. an die Montan-Industriewerke GmbH betreffend Betriebsstillegungen und Verlagerungen. February 1945. Private Collection Preuss.

Schaefer, Karl Wolfram, Frank Boeren, Sergei Boutsev, et al. 1997. Internationale Erfahrungen der Herangehensweise an die Erfassung, Erkundung, Bewertung und Sanierung Militärischer Altlasten. *UBA Text* 4 (97): 139–144.

Schmaltz, Florian. 2005. *Kampfstoff-Forschung im Nationalsozialismus. Zur Kooperation von Kaiser-Wilhelm-Instituten, Militär und Industrie*. Göttingen: Wallstein.

Scholz, Ernst-Gerhardt. 2004. Stoltzenberg-Skandal. Zuerst starb ein Kind. *Hamburger Abendblatt,* September 7.

Schreiben der Luranil-Baugesellschaft mbH (in Auflösung) an das IG Farben Control Office (Liquidation section), Frankfurt am Main betreffend Silbermaterial. January 18, 1951. Private Collection Preuss.

Schreiben der Waffenamt-Forschungsabteilung (WaF) an den Chef Wa J Rü betreffend Muna-Ost. December 1938. Private Collection Preuss.

Schreiben der Waffenamt-Forschungsabteilung (WaF), Nr. 595/39 gKdos Wa F/A2, an Wa J Rü 10 und Wa J Rü (Mun3) betreffend MO, Büro Prof. Loos. January 30, 1940. Private Collection Preuss.

Schreiben des Oberkommandos des Heeres (Ch H Rüst u BdE), 70 o 30 18 Wa J Rü (Mun 3 zbV/VIII), Nr. 10006/43 g.Kdos., an I.D. Riedel - E. de Haen AG, Berlin-Britz betreffend Sonderbauvorhaben OKH. February 18, 1943. Private Collection Preuss.

Schreiben des Oberkommandos des Heeres (Ch H Rüst u BdE), Wa J Rü Stab IV d an das Oberkommando der Wehrmacht (OKW), W Stab W Rü, betreffend M.-O., Falkenhagen, Erwerb von Flussspatgruben, Antrag auf Bestimmung einer Bedarfsstelle. January 1940. Private Collection Preuss.

Schreiben von Oberst a.D. Hammer, Falkenhagen an die Verwertungsgesellschaft für Montanindustrie GmbH, München. September 18, 1943. Private Collection Preuss.

Schweer, Henning. 2008. *Die Geschichte der Chemischen Fabrik Stoltzenberg bis zum Ende des Zweiten Weltkrieges. Ein Überblick über die Zeit von 1923 bis 1945 unter Einbeziehung des historischen Umfeldes mit einem Ausblick auf die Entwicklung nach 1945*. Diepholz: GNT Verlag.

Sekretariat K, Bericht, Betrifft: Orgacid GmbH Der Betrieb liegt still und hat eine amerikanische Wache von etwa 30 Mann. Die Orgacis beschäftigt 42 Arbeiter…, Essen, May 28, 1945. Private Collection Preuss.

Sonderausschuss C beim Reichsminister für Rüstung und Kriegsproduktion, Bericht über die Lage auf dem Kampfstoffsektor, Auszug aus dem Vortrag im Führerhauptquartier am 15.03,1943 mit einer Gegenüberstellung der Situation vom 01.03,1944, March 3, 1944. BArch Berlin, R 3/1894.

Sonderausschuss C, Arbeitsbüro: Fertigungsbericht C-Stoffe für Dezember 1944. BArch Berlin, R 3/1894.

Spezialstab ATV, Gruppe Ausbildungsmaterial, Kampftruppenschule 2, 90 Jahre Truppenübungsplatz Munster 1883–1993, 6–21, Munster 1983.

Stoltzenberg, Dietrich. 1994. *Fritz Haber—Chemiker, Nobelpreisträger, Deutscher, Jude*. Weinheim: VHC Wiley.

Szöcs, Andreas. 1999. *Geoökologische Systemanalyse und Bestimmung der Nitroaromatenmobilität auf dem großflächigen Rüstungsaltstandort Stadtallendorf bei Marburg*. PhD dissertation, University of Mainz, Göttingen: Cuvillier Verlag.

Thieme, Jürgen. 1996. Bestandsaufnahme von Rüstungsaltlastverdachtsstandorten in der Bundesrepublik Deutschland. *UBA Text* 25/96-30/96.

Thieme, Jürgen. 1999. Umweltrelevante und technische Aspekte der Zerlegung von Munition und Waffen nach dem 1. Weltkrieg. *UBA Text* 3: 99.

Transcription of the copy from Handelsregister, Amtsgericht Halle an der Saale, Department B, December 23, 1937. Private Collection Preuss.

Verfügung der Landesregierung Brandenburg, Enteignungsurkunde für das beschlagnahmte Betriebsvermögen der Firma M.O. Falkenberg (!), Falkenberg, Kreis Lebus. July 7, 1848. Private Collection Preuss.

Vertrag zwischen dem Deutschen Reich (Wehrmachtsfiskus), vertreten durch das Oberkommando des Heeres (OKH), der Verwertungsgesellschaft für Montanindustrie GmbH, der IG Farbenindustrie AG und der Monturon GmbH über die Erweiterung der OKH-eigenen N-Stoff-Anlage durch eine Fabrikationsstätte zur Herstellung von 500 metric tons monthly Sarin. June 3, 1944. Private Collection Preuss.

Vertrag zwischen der Chemischen Fabrik Buckau (Ammendorf), der Degea-Aktiengesellschaft (Auergesellschaft), Berlin, und dem Deutschen Reich (Fiskus des Wehrmachtsteils Heer), vertreten durch den Reichskriegsminister (Rkm) über die Errichtung einer Polyglykolfabrik und einer Umsetzungsanlage. September 20, 1935. Private Collection Preuss.

Wehrmacht-Fernsprechverzeichnis Groß-Berlin Teil I, p. 147. February 1, 1943. National Archives, Washington DC., Microfilm T-77, reel 342.

Wehrmachts-Fernsprechverzeichnis Groß-Berlin, Ministerial Dirigent Dr. Zahn Abteilungs- Chef z. b. V, Abteilung Chef-Chemiker (Wa A). June 6, 1943, part I, p. 144. National Archives, Washington, DC., Microfilm T-77, reel 342.

Williams, C., Burning of Mustard Gas and Lewisite at No. 81 M.U., R.A.F., Bowes Moor, Estimation of Risk. Summary of Porton Report No. 2744. January 1, 1947. National Archives, Washington, DC., RG 338.

Zimmermann, K., and H. Martens. 1994. Kontamination von militärischen Gelände im Raum Munster durch Arsenverbindung. *Abfallwirtschaftsjournal* 6 (6/7): 510–513.

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From Charles and Francis Darwin to Richard Nixon: The Origin and Termination of Anti-plant Chemical Warfare in Vietnam

Matthew Meselson

Abstract Anti-plant chemical warfare (CW), the use of chemicals to clear vegetation or destroy food crops as a method of warfare, was conducted on a large scale in the Vietnam War of the 1960s and 1970s. Unlike the anti-personnel CW of World War I, which continued until the Armistice, anti-plant CW in Vietnam was terminated while the war was still underway. Already subject to increasing controversy, its limitation and subsequent termination was precipitated by the appearance in late 1969 of a government-sponsored study suggesting that 2,4,5-T, a component of Agent Orange, the herbicide most heavily used for defoliation, might be teratogenic to humans. In consequence, its use in Vietnam was restricted and then prohibited altogether. Although another herbicide, Agent White, remained briefly in use, all large-area defoliation had ceased by May 1970, leaving crop destruction as the remaining form of large-area herbicide operations in Vietnam. After a review of the program requested by the U.S. Ambassador and the Commanding General in Saigon, the ambassador telegraphed Washington in early December 1970 their decision that chemical crop destruction should be phased out. Although secret, the content of the telegram became known to the press and was published a week later, followed shortly thereafter by President Richard Nixon's announcement that there would be "an orderly yet rapid phaseout of herbicide operations in Vietnam."

The development of anti-plant chemical warfare (CW) may be traced to discoveries made by Charles Darwin and his son Francis, described in their book "The Power of Movement in Plants," published in 1880 (Darwin and Darwin 1880; Holland et al. 2009). They found that the bending of oat and canary grass seedlings (specifically, the cotyledons) toward a light source does not occur if the tip of the seedling is shielded from light or excised. Observing that the bending occurs a short distance away from the tip, they concluded that "some influence is transmitted from the upper to the lower part, causing the latter to bend." They also repeated and

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confirmed disputed experiments by others, showing that the downward bending of roots in response to gravity is likewise "due to an influence transmitted from the apex to the adjoining part where the bending takes place."

Investigations early in the twentieth century showed the "influence" to be a material substance. Bending in response to light was found not to occur if the tip is separated by a thin sheet of mica from the region where bending would otherwise occur but does occur if the severed parts are separated instead by a layer of gelatin, through which a chemical substance might diffuse. The isolation and identification of the presumed substance was facilitated by the further discovery that a small block of agar that has been placed on the upper cut surface of a seedling cut through near the tip, when placed on one side of the lower surface, causes bending in the direction away from that side. This was interpreted to mean that a growth-promoting substance adsorbed in the agar block is transported downward on that side of the seedling, where it causes the observed bending. The angle of bending under defined conditions provided a quantitative assay for the growth-promoting substance that was then used to guide its isolation from two sources known to have such activity: human urine and the fungus *Rhizopus suinis*. The highly active substance isolated from both sources was found to be indole-3-acetic acid (IAA). Only much later was it established that IAA is the major naturally-occurring plant hormone involved in heliotropism and geotropism (Whippo and Hangarter 2006; Abel and Theologis 2010; Enders and Strader 2015).

Although IAA stimulates plant growth at low doses, higher doses were found to cause plant death. In 1941, Ezra J. Kraus, chair of the Botany Department at the University of Chicago, proposed that plant growth regulators might therefore find use as selective herbicides in agriculture and began a screen for compounds more stable than IAA that might be used for such purposes. Following Kraus' suggestion, a parallel screening program was undertaken at the U.S. Agricultural Research Center at Beltsville, Maryland under the direction of one of his former doctoral students. Late that year, in a memo written a few days after U.S. entry into WWII, Kraus proposed to a committee of the National Academy of Sciences formed to advise the War Department on biological warfare that a program be established to develop herbicides that might provide a "simple means of destruction of rice crops, the staple food supply of the Japanese" and which applied as "sprays or mists over enemy forests would, through the killing of trees, reveal concealed military depots" (Kraus 1942; Peterson 1967; Troyer 2001).

It had been found in 1942 that 2,4-dichlorophenoxyacetic acid (2,4-D) is a potent stimulator of plant growth (Zimmerman and Hitchcock 1942). But its powerful herbicidal activity and potential as a weed killer, discovered independently in Britain and in the U.S., remained secret until late in the war. Kraus, upon learning of the plant growth activity of 2,4-D, included it in the screens underway at Chicago and at Beltsville, thereby becoming one of the discoverers of its potential for use as an herbicide (Troyer 2001). Conducted under conditions of wartime secrecy, the work at Chicago was done in the University's botany department, just around the corner from the west stands of the track and football field where in the winter of 1942 Enrico Fermi and his colleagues were building the world's first nuclear reactor.

Starting in 1944, a large-scale project to screen chemicals for herbicidal activity and for plant species specificity and to develop methods for their military application was begun by the U.S. Army Chemical Warfare Service at the Army Biological Research Center at Camp (later Fort) Detrick, Maryland, established the year before. The main effort was on crop destruction with only limited work on defoliation. By late 1945, some one thousand substances had been tested for use against various food crops at Detrick or under its direction in field tests elsewhere in the U.S. Of the agents tested, 2,4-D and 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) were considered to be the most effective, although later work showed them to be less so against grain crops. By the end of the war, substantial stocks of 2,4-D and other herbicides and equipment for their dissemination by aircraft had been procured but were not used in any theater. After the war, except for a severe cutback in 1957, reversed the following year, research and field testing continued on a substantial scale. Following aerial spray tests conducted in the 1950s at the U.S. Army chemical and biological proving grounds at Dugway, Utah, and in 1959 at Camp Drum, New York, formulations of 2,4-D and 2,4,5-T were chosen as defoliants and the plant metabolic disrupter and desiccant cacodylic acid (dimethylarsenic acid), more toxic for grain crops, was selected for use against rice and wheat (Cecil 1986; Young 2009).

Thus, unlike the anti-personnel CW of World War I, which began with little prior development and no established advocate organization within the military, anti-plant CW in Vietnam was preceded by many years of research, development, and testing by a dedicated organization within the U.S. Army. Further, a precedent had been set for anti-plant CW by the use of herbicides, mainly 2,4,5-T, for crop destruction and defoliation in British counterinsurgency operations in Malaya in the early 1950s (Connor and Thomas 1984).

Experimental testing of chemical crop destruction and defoliation in Vietnam began in August 1961 and continued until mid-January 1962 as part of Project Agile of the U.S. Defense Department's Advanced Research Projects Agency (ARPA), supported by the Crops Division of the Army Chemical Corps at Detrick (Brown 1962). The initial impetus for introducing herbicide warfare in Vietnam appears to have come from William H. Godel, an ARPA Deputy Director acting with the encouragement of Vietnam President Ngo Dinh Diem and assisted by the director of Detrick's Crops Division (FRUS 1961; Godel 1961; Brown 1962; Bundy 1972; *Washington Post* 1966). In the first tests, on August 10, 1961, a mixture of the n-butyl esters of 2,4-D and 2,4,5-T and the isopropyl ester of 2,4,5-T, known as Agent Purple, was sprayed by helicopter over manioc and rice fields and over roadside trees. While the tests were still underway, the Chief of the U.S. Military Assistance Advisory Group recommended to the Department of Defense in Saigon in October 1961 that defoliation and crop destruction be carried out against several designated targets (Olenchuk et al. 1963). In the following month, the Joint Chiefs endorsed a plan developed in Saigon to spray 334 square miles of manioc and rice with 2,4,5-T and cacodylic acid and defoliate 200 square miles of forest with 2,4-D and 2,4,5-T, warning, with respect to crop destruction, that “care must be taken to assure that the United States does not become the target for charges of employing chemical or biological warfare” (Buckingham 1982).

Late that same month, on November 30, 1961, responding to recommendations from the Deputy Secretary of Defense and the Secretary of State, President Kennedy agreed in principle to chemical defoliation and crop destruction in Vietnam, but on a far more limited and tightly controlled basis than had been envisaged by the Joint Chiefs, authorizing only a

> selective and carefully controlled joint (with the Republic of Vietnam) program of defoliant operations […] proceeding thereafter to food denial only if the most careful basis of resettlement and alternative food supply has been created (Bundy 1961; Buckingham 1982).

Limited defoliation on an operational basis (intended to have a military effect rather than being only developmental) was begun early in January, after Kennedy reduced to only 16 miles the plan for defoliation of about 300 miles of roadside that had been submitted to him by the Departments of Defense and State. Authority to approve defoliation missions was retained in Washington until November 1962, when authority for defoliation of limited areas was delegated to the U.S. ambassador and the commander of U.S. forces in Vietnam, followed in May 1963 by the delegation to them of authority for all defoliation. Crop destruction was not authorized until October 1962. It required State and Defense Department authorization throughout the Kennedy administration and until July 1964, when it was delegated to Saigon (Collins 1967; Warren 1968; Clary 1971; Buckingham 1982; Cecil 1986).

Altogether, according to updated estimates, about 73 million liters of various herbicides were sprayed by fixed-wing aircraft and helicopters over an area of approximately 26,000 km^2, 15 percent of the land area of the Republic of Vietnam, most of it sprayed more than once. Most of the area sprayed was coastal or inland forest while about 10% was crop land. Of the total volume sprayed, about 63% was Agent Orange (a mixture of the n-butyl esters of 2,4-D and 2,4,5-T or, in smaller quantity, containing the iso-octyl rather than the n-butyl ester of 2,4,5-T), 28% Agent White (a mixture of 2,4-D and a chlorinated derivative of picolinic acid plus inert ingredients), and 7% Agent Blue (cacodylic acid and its sodium salt plus inert ingredients), and a few percent of other compounds or formulations that were employed mostly before the introduction of Agent Orange in 1965. After a gradual buildup in herbicide operations in earlier years, nearly 80% was dispensed in the four years 1966–1969, followed by a sharp drop in 1970, after the restriction and then cancellation of authorization for the use of Agent Orange (Buckingham 1982; Westing 1984; Stellman et al. 2003; Young 2009).

The limitation and subsequent cessation of the use of Agent Orange was precipitated when a study of possible carcinogenic, teratogenic, and mutagenic effects of a large number of pesticides and industrial chemicals was brought to the attention of the administration. The study, dated August 1968 and released to the public the following year, was commissioned by the U.S. National Cancer Institute and done by the Bionetics Research Laboratories of Kensington Maryland (Bionetics Research Laboratories 1968). It found that 2,4,5-T administered to pregnant mice and rats consistently caused a high frequency of malformations and death in fetuses and newborns and categorized 2,4,5-T as "probably dangerous."

Although the Bionetics report would have soon come to the attention of the White House one way or another, the swiftness of the response when it was brought to the attention of the President's Science Advisor is noteworthy. In the autumn of 1969, I was given a pre-release copy of the report. Aware of articles in Saigon newspapers claiming that herbicide exposure was causing birth defects and believing that the administration should be made aware of the Bionetics report, I and two colleagues called upon Lee DuBridge, the physicist and former president of CalTech who was then President Nixon's Science Advisor (Primack and von Hippel 1974; Hay 1982). After examining the report and while I was still with him in his office, DuBridge telephoned the Deputy Secretary of Defense, David Packard (co-founder of the Hewlett Packard Corporation), and they agreed on the spot to restrict the use of 2,4,5-T. In a White House press release late that same day, October 29, DuBridge announced that the Defense Department "will restrict the use of 2,4,5-T to areas remote from population"; that the Department of Agriculture "will cancel registrations of 2,4,5-T for food crops effective January 1"; and that the Departments of Agriculture and Interior "will stop using 2,4,5-T in their own programs" (Nelson 1969a, b). A few days later, DuBridge telephoned me at Harvard to say that representatives of the Dow Chemical Company had informed him that the likely teratogen was not 2,4,5-T itself but rather a highly toxic impurity, dioxin (2,3,7,8-tetrachlorodibenzodioxin). Dow had known of its toxicity following an outbreak of chloracne among workers at a Dow facility in 1964 (Baughman 1974; Crummett 2002). Dioxin is formed as an impurity in the Dow synthesis procedure for 2,4,5-trichlorophenol, a precursor of 2,4,5-T, particularly if carried out at too high a temperature (Young 2009). Knowing this, Dow had taken precautions to keep the concentration of dioxin in 2,4,5-T below 1 ppm. As found in research done much later, the extreme toxicity of dioxin is associated with its avid binding to a molecular receptor that regulates the expression of numerous genes (IOM 2014; Sorg 2014).

It was later found that the 2,4,5-T employed by Bionetics, not produced by Dow, contained 27 ppm of dioxin. Further tests were therefore undertaken to determine if purer 2,4,5-T also causes birth defects in rodents. Finding that 2,4,5-T containing only about 1 ppm of dioxin did so in mice, the Secretaries of Agriculture, Interior, and Health, Education and Welfare agreed in an announcement of April 15, 1970 to suspend registrations for uses of 2,4,5-T on agricultural land and in places likely to entail direct human exposure (US Department of the Interior 1970). Simultaneously, undersecretary Packard canceled authorization for all uses of Agent Orange in Vietnam. The cancellation of Agent Orange put a stop to nearly all large-area chemical defoliation, leaving only a few occasions on which Agent White, available in only limited supply, was used in this mode, bringing an end to all defoliation, except on the perimeters of fixed US installations, in May 1970 (Buckingham 1982).

While large-area defoliation had ceased, chemical crop destruction continued. Although strongly supported by the Joint Chiefs and the Secretary of Defense (Laird 1970), it was controversial ever since it had been conditionally authorized by President Kennedy in 1961. A 1968 interagency review of the herbicide program ordered by the U.S. ambassador in Saigon, Ellsworth Bunker, concluded that

> There is evidence that food shortages, for which crop destruction efforts were partly responsible, have at times created logistical problems for the enemy […] The main impact of crop destruction, however, falls upon the civilian population […] An estimated 90% of the crops destroyed in 1967 were grown, not by VC/NVA military personnel, but by civilians living there (American Embassy Saigon 1968; Clary 1971; Buckingham 1982).

The year before, a study of the military utility of the crop destruction program, based on some 2400 interviews conducted with Vietnamese familiar with the activities of the Viet Cong and the North Vietnamese army concluded that "the data consistently suggest that the crop destruction program has not in any major sense denied food to the VC" and that "the crop destruction effort may well be counterproductive. The VC continue to feed themselves while the peasant bears the brunt of the deprivation" (Betts and Denton 1967).

In 1972, after all aerial herbicide operations had ceased, Packard directed the Army Corps of Engineers to conduct a study of the military utility of herbicides in Vietnam. Based on a survey of U.S. military officers who had served in Vietnam, on the association of roadside defoliation missions with recorded friendly and enemy battle fatalities, and on earlier studies, the Engineers study concluded with respect to defoliation that "[h]erbicides were useful in supporting military operations in selected instances" and that "[m]any survey responses report that the use of herbicides around the perimeter of bases and installations is the most effective use of herbicides in Vietnam." Regarding crop destruction, the study concluded that "[h]erbicides destroyed enemy crops, but the enemy was able to compensate and overcome localized food supply shortages. At most, the crop destruction program harassed the enemy" (ESSG 1972).

An example of problems encountered in attempting to distinguish fields cultivated by military units from fields cultivated by civilians for their own consumption was encountered by a colleague and myself in August 1970. For five weeks in the summer of 1970, I was in Vietnam on behalf of the American Association for the Advancement of Science as part of a small team conducting a preliminary survey of the ecological and health effects of the military use of herbicides in Vietnam—interviewing farmers, photographing sprayed and not-sprayed forest, and collecting environmental and biomedical samples for mass spectrometric analysis for dioxin at Harvard (Constable and Meselson 1971; Meselson et al. 1972; Meselson and Baughman 1973, 1974). In order to inspect an area where crop destruction had recently taken place, the medical member of our team, Dr. John Constable, and I were flown by helicopter over a river valley in one of the northern provinces where Agent Blue had been sprayed along a 15 km path a few days before (Fig. 1). Flying along the length of the valley on two occasions, we saw rice fields browned by the herbicide but were too high to see much evidence of habitation. As indicators that the valley

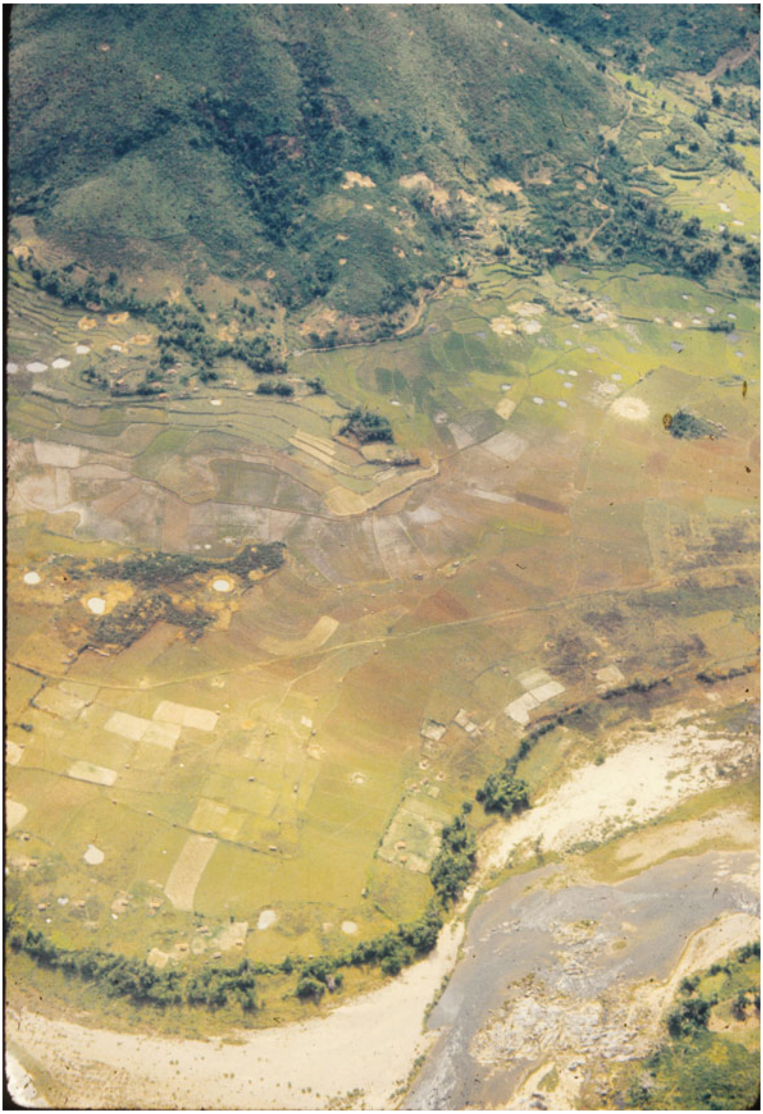

Fig. 1 Aerial photograph of a portion of a valley sprayed with Agent Blue in August 1970. Many small dwellings may be seen throughout the valley. Terraced fields may be seen on the hillsides. In order to suppress groundfire against the slow and low-flying UC-123 spray aircraft, spray missions were generally preceded by fighter aircraft delivering 500 or 750 lb bombs, cluster bomb units, 20-mm ordnance, and/or napalm (Buckingham 1982). From the Meselson CBW Archive

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

AAAS HERBICIDE ASSESSMENT COMMISSION
BOTANICAL MUSEUM, HARVARD UNIVERSITY
CAMBRIDGE, MASSACHUSETTS 02138, U.S.A.

MATTHEW S. MESELSON, CHAIRMAN
ARTHUR H. WESTING, DIRECTOR

12 November 1970

The Honorable Ellsworth Bunker
American Ambassador
Saigon, Republic of Vietnam
APO San Francisco, California 96243

Dear Ambassador Bunker,

On behalf of the Herbicide Assessment Commission of the American Association for the Advancement of Science, we wish to express our appreciation for the generous assistance provided by the Embassy during our recent tour of the Republic of Vietnam.

We are now preparing our report for presentation to the AAAS at the end of December and will send a copy to you as soon as it is available. Before that time, however, we wish to relay some observations that we believe merit your more immediate attention because they challenge the basis of the current chemical crop destruction program.

On August 21 and 28 we overflew an area in Quang Ngai province where chemical crop destruction operations had been conducted a few days before. The responsible chemical operations staff officer accompanied us on one of the overflights, and we spoke at length with other officers and civilian officials on the scene. It was explained to us that the targets were VC/NVA crop production areas and that most of the food destroyed would otherwise have been consumed by enemy forces. The reasons given for this assessment were that

1. The target area had only a very low population density.

2. The area under cultivation had expanded strikingly in recent years.

3. The cultivated area was much larger than that needed to support the small indigenous population.

4. The existence of numerous terraced rice fields indicated the influx of VC/NVA food production units, since the Montagnards who comprise the native population do not practice terracing.

Our observations are sharply at variance with all four of these points.

Fig. 2 Letter sent to Ambassador Ellsworth Bunker, General Creighton Abrams and Secretary of State William Rogers, November 12, 1970. From the Meselson CBW archive

- 2 -

Background information. One of the target areas is shown in photograph 1. Three C123 aircraft sprayed herbicide along the Song Re river valley from map coordinates BS 3455 to BS 3543. The photograph was taken near the latter coordinate, looking northward up the valley. The spray swaths are generally visible as brown streaks. Spraying was conducted continuously for a distance of about ten miles, resulting in coverage of approximately 1000 acres. Photographs 2 and 3 show the ground more closely. Numerous craters have been caused by the preparatory laying down of maximum suppressive fire, including the application of 300 per cent saturation with cluster bomb units, a measure required by the Seventh Airforce to protect the slow-flying C123's against hostile ground fire. Many dwellings may be seen in both close-ups, especially in photograph 3. The site of each of the photographs is indicated on the accompanying 1:50,000 scale U.S. Army map.

Population density. The map shows a high population density throughout the target area. In the twenty-seven 1 km^2 grid boxes through which the spraying passed, there are more than 900 dwellings, indicated as small black squares. Detailed comparison of the map with photographs 2 and 3 suggests that the number of dwellings in the target area is at least as great as it was in 1965, the year in which the map was last revised. Assuming, for example, an occupancy of six persons per dwelling, the population in the sprayed area would be approximately 5,000. This corresponds to 180 persons per square kilometer, hardly a low population density.

Expansion of cultivated area. The boundaries of cultivated fields on the enclosed map (and also on a matching 1:20,000 scale pictomap) agree well with the boundaries seen in our photographs, offering no evidence for any major expansion of crop production since 1965. Also, the fields seen in the photographs look well established and not of recent origin.

The question of surplus. The amount of land under cultivation in the target area may be estimated from the map to be approximately 800 hectares, about one hectare for each dwelling. Contrary to the view that a large surplus of food was being grown in the valley, one hectare of mountain land is just about enough to sustain a family unit.

Significance of terraced fields. Authoritative DoD publications on the Montagnard peoples as well as knowledgeable officials in Saigon state that the Montagnards of Quang Ngai, the Hre, have long grown rice on terraced fields.

We realize that this particular crop destruction mission may have been atypical. However, it was cited by the chemical staff officer and other officials as being particularly effective and well planned.

Moreover, our observations lend additional weight to several official studies done in Vietnam which have concluded that nearly all of the food destroyed by the chemical crop destruction program would normally be consumed by civilians, not by enemy soldiers.

Fig. 2 (continued)

As to the scale of the present crop destruction program, we were distressed by the implications of an analysis prepared by the GVN at the province level estimating the quantity of rice and other crops marked for chemical destruction under the 1970-71 herbicide program. Including missions requested by U.S. elements as well as those requested by the Vietnamese themselves, the total quantity of food scheduled for destruction is placed at 14,575 metric tons in Quang Ngai and Quang Tin provinces alone. This should be enough to sustain some 50-70,000 persons for a year. The targets are located mainly in upland regions where Montagnards are the traditional population. The Special Commission for Highland Affairs estimates the total Montagnard population of the two provinces as just under 70,000. Therefore if the areas we inspected are any indicator, the destruction of so much food or even of any substantial fraction of it would have devastating consequences for the Montagnard peoples of Quang Ngai and Quang Tin and for indigenous peoples in other provinces where similar conditions may prevail.

While we were in Quang Ngai province we had several occasions to interview Montagnard refugees whose lands had recently been sprayed with herbicide. We were impressed with the way in which they perceive the use of the chemicals. Apparently when the land is effected by herbicides, the Hre people consider it to be the manifestation of an evil spirit, and according to their tradition will abandon such land in the belief that it has fallen under a curse. Thus the folk beliefs of the Hre may intensify the effects of the crop destruction program on their lives.

Before leaving Vietnam we made a preliminary report of our observations to General Abrams and to Mr. Stephen Winship and Mr. Terence Grant of the Embassy Political Military section. Upon our return, one of us was requested to present a briefing at the State Department in Washington. The briefing took place on October 19 before a working level group consisting mainly of personnel from the Bureau of East Asian and Pacific Affairs and the Bureau of Intelligence and Research. We are also sending copies of this report to Secretary Rogers and to General Abrams.

We strongly hope that our observations can make a positive contribution toward bringing under review a program which seems to us very much in need of it.

Sincerely yours,

Matthew Meselson

John Constable

was an enemy food-production area, not home to a civilian population, the Chemical Corps officer who accompanied us in the helicopter and who had participated in planning the mission explained that the area under cultivation far exceeded the needs of the sparse population in the valley, that there had been a recent major expansion of rice fields, and that the presence of terraced rice fields on the hillsides, a form of rice culture practiced by ethnic Vietnamese but not by the indigenous Montagnard tribespeople, indicated that the area was an enemy crop production site.

Upon returning to the U.S., examining the high-resolution photographs we had taken from the air, comparing them with U.S. Air Force photographic coverage of the valley done in 1965 and consulting the Army's handbook on the Montagnard tribes of Vietnam and other sources, we found that all of the evidence for enemy crop production cited by the Chemical Corps officer was inaccurate or incorrectly interpreted. We therefore sent a letter describing our observations and a set of our photographs of the sprayed rice fields to Ambassador Bunker and General Creighton Abrams, Commander of U.S. forces in Vietnam and Secretary of State William Rogers (Meselson and Constable 1970) (Fig. 2). I had previously given a briefing on our observations at the State Department Bureau of Intelligence and Research and, in mid-December, had described our findings to President Nixon's National Security Advisor, Henry Kissinger (Guhin 1970; Hydle 1970; Buckingham 1982).

In November 1970, Bunker and Abrams initiated a review of the herbicide program with particular emphasis on crop destruction (Interagency 203 Committee 1970). After considering the resulting report they sent a telegram to Washington on December 9, saying they had decided that the crop destruction program should be phased out (Bunker 1970). Their recommendation leaked to the press and was published the following week (Jay 1970). On December 26, the day on which we reported our observations in Vietnam to the annual meeting of the American Association for the Advancement of Science in Chicago (Boffey 1971), President Nixon announced that "Ambassador Bunker and General Abrams are initiating a program for an orderly, yet rapid phase-out of the herbicide operations" and that during the phase-out, the use of herbicides in Vietnam would be restricted to perimeters of firebases and US installations or remote unpopulated areas (Office of the White House Press Secretary 1970). The last crop destruction mission was flown on January 7, 1971 (Cecil 1986; Young 2009). Thus, the large-area use of herbicides in Vietnam, already greatly reduced in 1970, came to an end at the start of the following year, two years before the Paris ceasefire agreement of January 1973 terminating direct US combat support for the Republic of Vietnam.

Two years later, in April 1975, President Gerald Ford proclaimed that

> The United States renounces, as a matter of national policy, first use of herbicides in war except use, under regulations applicable to their domestic use, for control of vegetation within U.S. bases and installations or around their immediate defensive perimeters (Executive Order 1975).

Postscript

While in Vietnam, I heard a spectrum of opinion from military officers, from pro to con, regarding the military utility of the herbicide program. A 1971 study conducted by the Department of Defense found that "[t]he military utility of herbicides has been conclusively established" (FRUS 1971). Particularly noteworthy, however, was the view expressed personally to me by General Creighton Abrams in his office in Saigon on September 3, 1970. "Do you want to know what I think? I think it's shit," he said, adding that his son John, then an Army captain who had served in Vietnam during 1967–69, was of the same view. When asked why the program continued even though he was Commander of U.S. forces in Vietnam, General Abrams replied that the decision to do so was made in Washington.

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References

Abel, Steffen, and Athanasios Theologis. 2010. Odyssey of auxin. *Cold Spring Harbor Perspectives in Biology* 2010 (2): a004572.

American Embassy Saigon. 1968. Report of the Herbicide Policy Review Committee, May 28. Meselson CBW Archive, Harvard University.

Baughman, Robert W. 1974. *Tetracholordibenzo-p-Dioxins in the Environment: High Resolution Mass Spectrometry at the Picogram Level*. Doctoral Dissertation, Harvard University.

Betts, Russell, and Frank Denton. 1967. *An Evaluation of Chemical Crop Destruction in Vietnam.* RAND Corporation, Santa Monica, CA, October 11. (RM-5446-ISA/ARPA). ADA032196. http://www.rand.org/pubs/research_memoranda/RM5446-1.html.

Bionetics Research Laboratories. 1968. *Evaluation of Carcinogenic, Teratogenic, and Mutagenic Activities of Selected Pesticides and Industrial Chemicals*. *Teratogenic Study in Mice and Rats*, vol II. Washington, D.C.: U.S. Department of Commerce. NTIS PB 223 160. http://www.nal.usda.gov/exhibits/speccoll/items/show/4100.

Boffey, Philip M. 1971. Herbicides in Vietnam: AAAS study finds widespread devastation. *Science* 171 (3966): 43–47.

Brown, James W. 1962. *Vegetational spray tests in South Vietnam.* Supplement. U.S. Army Chemical Corps Biological Laboratories, Fort Detrick, MD, April. AD368997. http://www.dtic.mil/cgi-bin/GetTRDoc?Location=U2&doc=GetTRDoc.pdf&AD=AD0368997.

Buckingham, William A. 1982. *Operation Ranch Hand: The Air Force and herbicides in Southeast Asia 1961–1971.* Washington, D.C.: Office of Air Force History, United States Air Force. ADA121709. https://media.defense.gov/2010/Sep/28/2001329797/-1/-1/0/AFD-100928-054.pdf.

Bundy, McGeorge. 1961. National Security Action Memorandum Number 115: Defoliant Operations in Vietnam, Nov 20. http://www.jfklibrary.org/Asset-Viewer/Z8-vBiaBdEW2Cz9g6NUB7g.aspx.

Bundy, William P. 1972. Recorded Interview by William W. Moss. John F. Kennedy Library Oral History Program, Mar 3. http://www.jfklibrary.org/Asset-Viewer/Archives/JFKOH-MGB-04.aspx.

Bunker, Ellsworth. 1970. Telegram to Secretary of State Washington. Subject: Herbicide Policy Review, Dec 9. Saigon 19374. Meselson CBW Archive.

Cecil, Paul F. 1986. *Herbicidal warfare: The Ranch Hand Project in Vietnam*. New York, London: Praeger.

Clary, James R. 1971. Project CHECO Report, Ranch Hand Herbicide Operations in SEA. Contemporary Historical Examination of Current Operations, Pacific Air Forces, July 13. ADA484753. http://www.dtic.mil/docs/citations/ADA121709.

Collins, Charles V. 1967. Project CHECO Report, Herbicide Operations in Southeast Asia, July 1961–June 1967, Oct 11. Contemporary Historical Examination of Current Operations, Pacific Air Forces. AD 779 796.

Connor, Steve, and Andy Thomas. 1984. How Britain sprayed Malaya with dioxin. *New Scientist* 101 (1393): 6–7.

Constable, John, and Matthew Meselson. 1971. The ecological impact of large scale defoliation in Vietnam. *Sierra Club Bulletin* 56: 4–9.

Crummett, Warren B. 2002. *Decades of dioxin: Limelight on a molecule*. Bloomington, IN: Xlibris.

Darwin, Charles, and Francis Darwin. 1880. *The power of movement in plants*. London: John Murray.

Enders, Tara A., and Lucia C. Strader. 2015. Auxin activity: Past, present, and future. *American Journal of Botany* 102 (2): 180–196.

Engineer Strategic Studies Group Office (ESSG). 1972. *Herbicides in military operations*, vol I, February. Washington, D.C.: Department of the Army. AD893214.

Executive Order. 1975. 11850. Renunciation of Certain Uses in War of Chemical Herbicides and Riot Control Agents, April 8. 40 Federal Register 16187.

Foreign Relations of the United States, 1961–1963, vol. 1, Vietnam. 1961. Document 96. https://history.state.gov/historicaldocuments/frus1961-63v01/d96.

Foreign Relations of the United States, 1969–1976, vol. E-2, Documents on Arms Control. 1971. Document 246. https://history.state.gov/historicaldocuments/frus1969-76ve02/d246.

Godel, W.H. 1961. Progress Report, Vietnam Combat Development and Test Center, September 13. Kennedy Papers, National Security File, Countries File, Vietnam (9/61) folder.

Guhin, Michael A. 1970. Memorandum to Henry Kissinger. Subject: Memcon of Meeting with Professor Meselson, Dec 17. Meselson CBW Archive.

Hay, Alastair. 1982. *The chemical scythe*. New York, London: Plenum.

Holland, Jennifer J., Diana Roberts, and Emmanuel Liscum. 2009. Understanding phototrophism: From Darwin to today. *Journal of Experimental Botany* 60 (7): 1969–1978.

Hydle, Lars H. 1970. U.S. State Department of Intelligence and Research. Memorandum to James D. Moffatt: Briefing by Matt Meselson on Herbicides, October 20. Meselson CBW Archive.

Institute of Medicine (IOM). 2014. *Veterans and Agent Orange: Update 2012*. Washington, D.C.: The National Academies Press. http://www.nap.edu/catalog/18395/veterans-and-agent-orange-update-2012.

Interagency 203 Committee. 1970. Report on the Herbicide Review, Nov 18. Hq. US MACV, Saigon.

Jay, Peter. 1970. US is urged to stop killing Vietnam crops. *Washington Post*, December 17.

Kraus, Ezra J. 1942. Plant Growth Regulators; Possible Uses, February 17. National Academy of Sciences Archives: Committees on Biological Warfare Records Group: WBC Committee: Report: Exhibit F,III. Plants 1.

Laird, Melvin. 1970. Memorandum for the Assistant to the President for National Security Affairs, Subject: United States Anticrop Warfare Program in Vietnam. With Enclosure: Assessment of the United States Anti-Crop Warfare Program in the Republic of Vietnam, July 18. Meselson CBW Archive.

Meselson, Matthew, and John Constable. 1970. Letter to Ambassador Ellsworth Bunker, November 12. Meselson CBW Archive.

Meselson, Matthew, and Robert Baughman. 1973. An analytical method for detecting TCDD (Dioxin): Levels of TCDD in samples from Vietnam. *Environmental Health Perspectives* 5: 27–35. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1474957/.

Meselson, Matthew S., Arthur H. Westing, John D. Constable, and Robert E. Cook. 1972. Preliminary Report and Background Material Relevant to Presentations at the 1970 Annual Meeting of the AAAS. Congressional Record, 92nd Congress, 2nd Session, vol. 118, part 6, Mar 3, 6806–6813.

Nelson, Bryce. 1969a. Studies find danger in defoliation herbicides. *Los Angeles Times*, October 30.

Nelson, Bryce. 1969b. Herbicides: Order on 2,4,5-T issued at unusually high level. *Science* 166 (3908): 977–979.

Office of the White House Press Secretary. 1970. President's Direction to Reduce the Use of Herbicides in Vietnam. Press Release, December 26.

Olenchuk, Peter G., Robert Burke, Oran Henderson, and Wayne Davis. 1963. *Task Force Saigon Herbicide Evaluation Team*. *Evaluation of Herbicide Operations in the Republic of Vietnam September 1962–September 1963,* October 10, 71–265, San Francisco: Military Assistance Commission, Task Force Saigon Herbicide Evaluation Team.

Peterson, Gale E. 1967. The discovery and development of 2,4-D. *Agricultural History* 41: 243–254.

Primack, Joel, and Peter von Hippel. 1974. *Advice and dissent: Scientists in the political arena*. New York: Basic Books.

Sorg, Oliver. 2014. AhR signalling and dioxin toxicity. *Toxicology Letters* 230: 225–233.

Stellman, Jeanne M., Steven D. Stellman, Richard Christian, et al. 2003. The extent and patterns of usage of Agent Orange and other herbicides in Vietnam. *Nature* 422: 681–687.

Troyer, James R. 2001. In the beginning: The multiple discovery of the first hormone herbicides. *Weed Science* 49: 290–297.

United States Department of the Interior. 1970. Press Release: Home Use of 2,4,5-T Suspended, April 15. http://www.nal.usda.gov/exhibits/speccoll/items/show/5799.

Warren, William F. 1968. A review of the herbicide program in South Vietnam. Alexandria, VA: Defense Technical Information Center, August. AD779797.

Washington Post. 1966. Embezzler Godel Sued to Repay Double, November 5, B4.

Westing, Arthur H. 1984. Herbicides in war: Past and present. In *Herbicides in war*, ed. Arthur H. Westing. London, Philadelphia: Taylor and Francis.

Whippo, Craig W., and Roger P. Hangarter. 2006. Phototropism: Bending towards enlightenment. *The Plant Cell* 18 (5): 1110–1119.

Young, Alvin. 2009. *The history, use, disposition and environmental fate of Agent Orange*. New York: Springer.

Zimmerman, P.W., and A.E. Hitchcock. 1942. Substituted phenoxy and benzoic acid growth substances and the relation of structure to physiological activity. *Contributions from the Boyce Thompson Institute* 12: 321–343.

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The Indelible Smell of Apples: Poison Gas Survivors in Halabja, Kurdistan-Iraq, and Their Struggle for Recognition

Karin Mlodoch

Abstract On March 16, 1988 the Iraqi Army of Saddam Hussein's Baath regime attacked the Kurdish town of Halabja with poison gas, killing an estimated 5,000 people within a few minutes. In today's autonomous region of Kurdistan-Iraq, the "martyrs' town of Halabja" has become a symbol for the suffering of Iraqi Kurdish people under the Baath regime and a key element of Kurdish national identity. At the same time, the people of Halabja continue to suffer from the long-term psychological, health, and environmental consequences of the poison gas attack. The present account is based on the author's longstanding research and practical work among survivors of violence in Kurdistan-Iraq. It outlines the background and impact of the chemical attack on Halabja and provides an insight into the survivors' situation—from the immediate aftermath of the attack to this day; it details the constant struggle of the victims with the long-term psychological effects of the attack as well as their struggle for justice and recognition of their experience.

1 Introduction: The Indelible Smell of Apples

In 1987 and 1988, the Iraqi Baath regime under Saddam Hussein used chemical weapons against the Kurdish population in Iraq. On March 16, 1988 the Iraqi Army attacked the Kurdish town of Halabja by poison gas and killed an estimated number of 5,000 people in a few minutes.[1] Before and after the attack on Halabja, poison

[1]No accurate body count could be made at the time. The casualty figures are based on the testimonies of survivors, Kurdish *peshmerga* and Iranian soldiers, Iranian medical personnel, and journalists present in the immediate aftermath of the attack, (Hiltermann 2008). Human Rights Watch researcher Shorsh Resool collected 3,200 individual names of victims in interviews with survivors, Human Rights Watch (1993, 108). Kurdish and Iranian estimates ranged between 4,000 and 7,000 victims at the time (ibid.). Today, the figure of 5,000 victims is commonly used by Iraqi Kurdish sources and in the national Kurdish discourse and referred to in official memorial ceremonies and monuments such as the Central Halabja Monument.

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gas was used in various other towns and villages during the so called Anfal Campaign of the Iraqi military against the Kurdish rural population in the border regions with Iran and Turkey, in the course of which thousands of villages were destroyed and some 100,000 people deported and killed. The Anfal Campaign is much less known to the outside world than the poison gas attack on Halabja.

The smell of apples is deeply imprinted into the memory of the survivors of poison gas attacks in Kurdistan-Iraq. All of them describe the intense smell of apples—or more precisely: the sweet smell of rotten apples that spread all over the place once the lethal poison-gas bombs touched the ground.

Visitors of today's Kurdistan-Iraq stumble over references to the apple as a memory symbol on many occasions. Apples decorated with cloves were traditionally used as a symbol of love and friendship in Kurdish communities; today, there is an additional tragic meaning to the symbol: the association with the lethal scent of chemical weapons. Visitors to the Ministry of Martyrs and Anfal Affairs in Erbil are given an apple studded with cloves with the inscription "a message of love and peace" as a gift. In the film "1001 Apples" by the late Kurdish director Taha Karimi (2013), survivors of the Anfal Campaign distribute apples to be decorated in remembrance of the victims. In the Zamwa Art Gallery in Sulaimania, a rocket shell with green apples gushing out of it like a waterfall symbolizes the Halabja attack. And at the 2015 ceremony for the victims of the chemical attack on Halabja at the Brandenburg Gate in Berlin, organized by Kurdish exile groups, young Kurdish women walked through the crowd of participants spraying air freshener with the scent of green apples to evoke the horror of the chemical weapons used.

2 Background

The Kurds often define themselves as the world's largest nation without a state. Indeed, after World War I and the collapse of the Ottoman Empire, their hopes for a Kurdish state were dashed and 30 million Kurds were scattered across five different nation states: Turkey, Syria, Iran, the former Soviet Union, and Iraq. Today, some 6 million Kurds live in Iraq alone and make up some 20% of Iraq's population. They inhabit a strategically important region of Iraq, rich in oil reserves and bordering on Iran and Turkey. There has been a conflict between the Kurds and the various Iraqi central governments at least since 1923.[2] The conflict with and the persecution of the Kurds intensified with the Baath Party's rise to power in 1968 and escalated when Saddam Hussein became president of Iraq in 1979. Saddam Hussein's regime spread a meticulous net of control, violence, and terror all over the Iraqi society, targeting Shia and Marsh Arab communities in the South, Kurds in the North and

[2]For the history of the Kurds in Iraq see McDowall (2004); van Bruinessen (1989).

political opponents of all ethnic and religious affiliations.[3] The Kurdish population in Iraq saw multiple waves of violence and persecution since the mid-1970s: Kurdish villages in border regions were evacuated and the population forcibly resettled; Kurds were expelled from oil-rich cities like Kirkuk and the regions repopulated by Arabs instead. Up to 1981 alone, 700,000 people had been forcibly displaced and relocated within the Kurdish areas (Vanly 1986, 163).

In 1980 Saddam Hussein led Iraq into a war with Iran that lasted eight years and left both countries devastated, with more than one million soldiers dead on both sides. Kurdish guerrilla fighters—the so-called *peshmerga*[4]—made use of the war situation, intensified their attacks against the Baath regime and entered into an alliance with Iran. The reprisals by the Baath regime reached genocidal proportions. In 1984, 8,000 men from the Kurdish Barzani tribe, the backbone of the Kurdish autonomy struggle during the 1960s and 1970s, were deported and killed—a prelude to the forthcoming episodes of mass killings in 1988 (Human Rights Watch 1993, 39–41). At the very end of the Iran-Iraq war, Saddam Hussein's regime threw its overblown military apparatus against the internal enemy: the Kurds.

3 The Anfal Campaign and the Poison Gas Attack Against Halabja in 1988[5]

In 1987 Saddam Hussein's cousin, General Ali Hassan al-Majid, was appointed General Secretary of the so called "High Office for Issues of the North" and assigned full military responsibility to—in al-Majid own words—"solve the Kurdish problem and slaughter the saboteurs" (Human Rights Watch 1993, 351). Al-Majid was the architect and commander of the so-called Anfal Campaign in 1988. Anfal is the title of the 8th sura of the Quran and served as a code word for a vast military operation against Kurdish rural areas where resistance fighters were active. The Anfal Campaign was planned long beforehand, openly announced, justified as punishment for the Kurds' cooperation with Iran, and meticulously documented by the regime. From February to September 1988 thousands of villages were razed to the ground. The population was rounded up; men between 15 and 60 and young women were separated from their families and deported to unknown destinations. For more than 15 years after Anfal, their fate remained unknown; the discovery of more than 300 mass graves after the fall of the Baath regime proved that these people fell victim to mass executions. Kurdish sources estimate the

[3]For a comprehensive analysis of the Baath regime's policy and repressive structure, see Farouk-Sluglett and Sluglett (1987); Al-Khalil (1989).

[4]Literally translated, the Kurdish term means "those who face death" and is used for Kurdish rebels and fighters, independently from their various party affiliations.

[5]A comprehensive documentation and analysis of the chemical attack against Halabja has been provided by Hiltermann (2007).

number of Anfal victims at 182,000.[6] As only a small number of the mass graves has been investigated, the individual fates of most of the victims are uncertain to this day.[7]

Elderly people and women with children were deported to detention camps and held there for months—many of them, especially children and the elderly, died. Those who survived were released in late autumn 1988 under what the regime called an “Amnesty” and forcibly resettled to so-called collective towns, where they continued to live under the control of the Iraqi Army (Human Rights Watch 1993, 306–311; Mlodoch 2014, 237–246).

In the course of the Anfal Campaign, the Baath regime used chemical weapons in dozens of locations (Human Rights Watch 1993, 22; Hiltermann 2007, 130); their use proved effective in making villagers flee in panic so that Iraqi soldiers could easily channel them towards concentration points, whence they were deported to be killed or detained (Hiltermann 2007, 130, 135).

Shortly after the beginning of the Anfal Campaign, on March 16, 1988, the Iraqi air force attacked Halabja, a Kurdish town of some 70,000 inhabitants located in the immediate proximity of the border with Iran, a reprisal for alleged joint cross-border operations of Iranian forces and Kurdish *peshmerga.* The town came under Iraqi attack days before by conventional weapons; therefore many of its inhabitants hid in provisional hand-dug underground air-raid shelters, basements or caves. These hideouts became deadly traps when the Iraqi Army threw tons of chemical agents on the town in the early evening of March 16.

The chemical attack lasted some 45 min. Survivors describe white-yellowish clouds that sank to the ground.[8] They describe the smell of apples[9]—some say it was rather a smell of garlic or banana, the sense of burning in eyes and on the skin, the inability to breathe.

An estimated 5,000 men, women, and children died a terrible death in Halabja. Many died immediately in the shelters or their houses; thousands ran out in panic to the streets and died there. Others tried to flee the town, but died minutes or hours later after “burning and blistering” and “coughing green vomit” (Human Rights

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[6]This figure is based on the number of villages destroyed during the Anfal Campaign and the average village population and is generally used by Anfal survivors, Kurdish politicians, and local academics. Human Rights Watch estimates the number of victims as at least 50,000 and “possibly twice that number” (Human Rights Watch 1993, 20) after evaluating survivors’ testimonies and the Baath regime’s own documents regarding the Anfal Campaign. The responsible military commander of the Iraqi regime, Ali Hassan al-Majid, is reported as having confirmed “not more than 100,000 victims” (ibid., 345).

[7]Background, preparations and course of the Anfal Campaign have been meticulously documented by Human Rights Watch (1993; 1994) based on survivors’ testimonies and the Baath-regime’s own documents. For the long-term impact of Anfal on the survivors see Mlodoch (2014).

[8]1988: Thousands Die in Halabja Gas Attack. *BBC News*, March 16, 1988. http://news.bbc.co.uk/onthisday/hi/dates/stories/march/16/newsid_4304000/4304853.stm. Accessed October 30, 2015.

[9]Halabja: Survivors Talk About Horror of Attack, Continuing Ordeal. *ekurd daily*, March 15, 2008. http://ekurd.net/mismas/articles/misc2008/3/independentstate2078.htm. Accessed March 10, 2016.

Watch 1991). Survivors report victims hysterically laughing moments before their death (ibid.). Some 7,000 were severely injured—their eyes and skin burned.

Due to the presence of Iranian and Turkish journalists at the time, photos of the victims have gone around the world, giving stirring evidence of the destructive effects of chemical weapons: scores of corpses of men, women, and children in unnatural positions spread all over the streets of Halabja; dreadfully distorted faces of children captured at the moment of death; disoriented survivors, wandering among the corpses, crying out for their loved ones; images of injured survivors with burned eyes and skin peeling off from their faces, arms, and legs in big pieces.[10] These photos have been important as evidence, but are unbearable to look at both for the horror they document and for the viewer's sense of violation of intimacy of the victims at the moment of their agonizing death. One photo among the many has become especially well known: that of Omeri Khawer who throws himself upon his baby child in a desperate attempt to protect him at the moment of death. The image has become an icon in Kurdistan-Iraq; the scene has been reproduced as a diorama in the Halabja Central Memorial and in a statue erected in the centre of Halabja.[11]

Eyewitnesses who clearly identified Iraqi airplanes as the ones that dropped the chemical bombs and the Baath regime's own documents which were later evaluated by Human Rights Watch give evidence about the responsibility of the Baath regime (Human Rights Watch 1993; Hiltermann 2007). The commander of the poison gas attack against Halabja was once again Iraqi General Ali Hassan al-Majid. Ever since, Iraqi Kurds refer to him as "Chemical Ali."

The injuries of the victims, the testimonies and symptoms of the survivors of the Halabja attack as well as specimen of unexploded bombs analyzed in the immediate aftermath prove the use of highly concentrated mustard gas,[12] combined with at least one nerve agent, probably sarin (Hiltermann 2007, 199).[13]

[10]For some of the photos see the website of the Kurdistan Democratic Party, http://www.kdp.se/halabja.html. Accessed March 10, 2016.

[11]The original photo was taken by the Turkish photographer Ramazan Öztürk in the immediate aftermath of the chemical attack in 1988. For the original photo and its reproduction as a statue, see: http://www.hurriyetdailynews.com/halabja-monument-opens-in-the-hague.aspx?pageID=238&nID=65792&NewsCatID=359. Accessed March 10, 2016. For the diorama at the Halabja Monument, see photo by Adam Jones: www.flickr.com/photos/adam_jones/5640509079/in/photostream and www.hurriyetdailynews.com/halabja-monument-opens-in-the-hague.aspx?pageID=238&nID=65792&NewsCatID=359. Accessed March 10, 2016.

[12]See also the interview with the Austrian physician Dr. Freilinger who treated Halabja survivors in 1988: Kurdistan Regional Government Representation Austria. Halabja: Interview with Dr. Freilinger. *KRG AT Media,* March 14, 2014. http://www.gov.krd/a/d.aspx?l=12&a=51117. Accessed October 30, 2015.

[13]At the time Iraq possessed sarin, tabun, and VX (United Nations Monitoring, Verification and Inspection Commission 2006). However, as there were no medical or forensic investigations in the immediate aftermath of the Halabja attack, the process of finding evidence on the exact substances used in Halabja has proven difficult and controversial. See: Elisabeth Rosenthal. In Iraq Chemical Arms Trial, Scientists Face Many Burdens of Proof. *New York Times*, June, 19, 2006. http://www.nytimes.com/2006/06/19/world/europe/19iht-chem.2001719.html?_r=0&pagewanted=all.

At the time, there was no immediate international response to the poison gas attack on Halabja. The U.S. and West European governments then still stood firmly behind Saddam Hussein in his war against the Iranian Islamic Republic, which was regarded as the greatest danger for the West at the time. The international community remained silent.

Thus, the Anfal Campaign and the use of poison gas had fulfilled the Baath regime's aims: the Kurdish resistance was defeated, the Kurdish population frozen in shock and disbelief at the scale of the terror they had experienced and paralyzed by the prospect of seeing another poison gas attack. The Kurds felt forgotten by the world.

4 The Situation of Survivors of the Poison Gas Attacks

4.1 Haunting Memories, Enduring Grief

Survivors of the poison gas attack on Halabja have all gone through highly traumatic experiences. Their homes, their families, their social structures, their entire world was destroyed in a few minutes. They witnessed their children, partners, parents, siblings dying a terrible death right in front of them, while being themselves injured, immobilized, struggling with death and thus unable to help them. Many struggle with feelings of guilt for not having been able to protect their children or for not having been able to attend to their relatives during their last moments and adequately mourn their death thereafter. Their concepts of themselves and the world were deeply shattered.

Kamaran Haider was 11 years old then and survived hidden in a makeshift shelter. He stayed there for many hours. When he left the shelter, he found his father, mother, and siblings lying dead on the stairs. "I lost my feeling, all my feeling," he recounts. "I knew that my mum died. I knew that my brother died […]. At that time, I didn't cry […]. I didn't feel anything. No happiness, no stress. Well, I knew that people around me died, that's it."[14]

Iranian soldiers and the Iranian Red Crescent took hundreds of survivors to Iran for medical treatment after the attack. There was an indescribable chaos, panic, and fear of more attacks to come and of the gas that was still lingering around. Injured and uninjured alike were hectically loaded on trucks and brought outside the town and into Iran. Many survivors lost track of their family members.

(Footnote 13 continued)

Accessed March 10, 2016. Hiltermann (2007, 183–205) gives a detailed account on the controversial process of fixing the evidence.

[14]Alfred Joyner. Kurdish Genocide in Iraq: Survivors Tell Their Stories. *International Business Times*, January 18, 2013. http://www.ibtimes.co.uk/kurdish-genocide-in-iraq-survivors-tell-their-stories-2028. Accessed March 10, 2016.

Many of the severely injured survivors spent years in Iran going from one hospital to another for medical treatment. Others were taken abroad for treatment—to Austria, Germany, and other countries, unaware of what happened to their relatives. A number of children, babies at the time, could not be identified by Iranian authorities and were adopted and brought up by Iranian families. In 2011, the heartbreaking story of Ali Pour was covered by Kurdish and international media and a documentary film (Hidou 2011).[15] Ali grew up as the son of an affectionate Iranian family. At the age of 21 he learned that he was originally a baby survivor of the poison gas attack in Halabja. He went back to Halabja in search of his original family. Three families claimed and hoped for Ali to be their lost son. The evidence provided by a genetic test led to an outbreak of joy in one family and to a new emotional breakdown in two others. Ali, whose original name is Zimnako Mohammed Salih, went the Halabja graveyard and erased his name he found engraved on one of the tombstones.[16]

To this day memories and images of the attack are deeply impressed upon the survivors' minds and thoughts. They suffer from what can be clearly defined as traumatic symptoms: nightmares, anxiety, restlessness, depression, panic attacks, flash-backs. Ako Sirini's documentary film "There is Hope Behind the Tears" (2013), based on testimonies of survivors, shows the intensity and presence of pain and grief in survivors twenty five years after the event. The young man, a child of maybe ten years in 1988, was taken to Iran with his siblings after the attack and spent weeks hoping and waiting for his parents to join them. He describes the moment of reunion with his uncle who brought certainty that his parents were dead: "Imagine at that young age, I did not cry because of the presence of the other children. From the day I received that news, I behaved differently. To this day, I haven't cried as much as my heart ached for them" (Sirini 2013, 10:46–11:11). A woman in her seventies stated: "When I think, every moment is like death for me. This pain is not like a soul; once it leaves, it never comes back. The pain lies within you forever" (Sirini 2013, 17:38–17:49).

4.2 Survivors' Life Conditions Between 1988 and 2003

We know from psychological trauma research that for victims of extreme violence and trauma the ability to recover and reconstruct their lives largely depends on the life conditions they find themselves in after the traumatic experience.[17] Safety,

[15]See also: Halabja Gas Attack Survivor Reunited With Mother. *BBC News Online*, December 5, 2009. http://news.bbc.co.uk/2/hi/8397547.stm. Accessed March 10, 2016.

[16]Other similar cases have been covered by both Kurdish and international media, see e.g.: Osamah Golpy. Halabja Child To Be Reunited With Family 3 Decades Later. *Rudaw*, August 18, 2015. http://rudaw.net/english/kurdistan/180820154. Accessed March 9, 2015.

[17]Psychoanalyst Hans Keilson was the first to draw attention to the significance of post-trauma life conditions for coping with traumatic episodes in his post-war studies of child Holocaust survivors in the Netherlands. He developed the concept of sequential traumatization (Keilson 1979).

economic and political stability, social support, societal and political recognition of their experience, and punishment or at least accountability of the perpetrators help victims of extreme violence to recover and find a balance between the past and the present. On the other hand, ongoing conflict and violence, poverty, impunity of the perpetrators, and a lack of assistance prolong and aggravate their suffering and keep them frozen in the moment of their trauma.[18]

The life conditions of the Halabja survivors in the years following the attack were more than adverse to any kind of recovery. First of all, many survivors died in subsequent years from their injuries.[19] Numerous others suffered from the long-term impact of the poison gas, from skin and eye diseases, damage to the respiratory and neural systems, and various forms of cancer, infertility, miscarriages and congenital disorders. Even in the third generation, the rate of leukemia is high among children (Gosden et al. 2001). The soil in and around Halabja will remain contaminated for a long time to come (Ala'Aldeen 2005).

Immediately after the attack, the Baath regime had razed the town of Halabja to the ground; there was no possibility of return. Many survivors stayed in Iran; others continued to hide in the mountains. The majority of survivors were forcibly resettled by the Baath regime in a so called *mujamma* (collective town) cynically named “New Halabja” at a distance of some 70 km from the destroyed town. Like other urban settlements built for Anfal survivors, “New Halabja” was a camp-like structure with housing, schools, and medical facilities. Its population lived under military control and was forbidden to leave and, especially, to set foot in Halabja.[20]

In 1991 a U.S.-led military coalition attacked Iraq in reaction to the latter's invasion of Kuwait. The Kurds in Iraq—seeing finally a chance to defeat the dictator—followed the U.S. call to arms, but were let down and abandoned by the coalition after its armistice with Iraq. The Kurdish insurrection was subsequently brutally crushed by Iraqi forces. At the moment of defeat, two million Kurds fled in utmost panic to Iran and Turkey, leaving behind all their belongings. The images of their mass exodus went around the world in the Spring of 1991. The panic among the fleeing Kurds could only be explained by their fear of further poison gas attacks that had been deeply imprinted into the minds of the Kurdish people in 1988.

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[18]The author refers to a socially and contextualized concept of trauma as developed in the work with Holocaust survivors, victims of torture and detention in Latin America and victims of political and gendered violence in various contexts. For an overview on the related concepts and debates see Mlodoch (2014, 29–66).

[19]Decades Later, Halabja Victims Still Dying of Wounds from Chemical Attacks. *Rudaw*, November 27, 2015. http://www.rudaw.net/english/kurdistan/271120153?keyword=Halabja&isArchive=True. Accessed March 10, 2016.

[20]Osamah Golpy. Tale of Two Cities: Halabja and New Halabja. *Rudaw,* March 24, 2015. http://rudaw.net/english/kurdistan/240320152. Accessed March 10, 2016.

In response to the mass exodus, Dutch and British troops set up safe havens for the refugees and the United Nations declared a no-fly zone over Iraq to prevent the Baath regime from carrying out airstrikes.[21] In the wake of these events the Kurds achieved provisional autonomy and a Kurdish government was democratically elected in 1992. Anfal survivors started to reconstruct their villages and Halabja poison gas attack survivors returned to their home town, from then on referred to by all Kurds as *Halabja shehid*—the "martyr's town of Halabja."

Despite these first steps toward their safety, the survivors would stay in precarious conditions for another twelve years. The Kurdish Regional Government had not been internationally recognized; the Kurdish region suffered from international sanctions against the whole of Iraq and an additional embargo from Baghdad imposed on the Kurds. There was no trustworthy agreement about Kurdish autonomy with the Iraqi regime, and the fear that the Baath-regime will come back was pervasive throughout those years. Iran and Turkey frequently intervened militarily in the unstable region and from the mid-1990s the two main Kurdish political parties, the Kurdistan Democratic Party (KDP) and the Patriotic Union of Kurdistan (PUK), engaged in a bloody internal struggle for power and resources that caused further violence and death in the region.[22]

During all those years until 2003, Halabja poison gas survivors lived in a city of ruins, in extreme poverty, facing multiple new waves of violent conflict, and fearing that the Baath regime will come back and the catastrophe will recur. Absorbed in a daily struggle for survival they had no possibility to rest, take care of themselves, reconstruct their town and lives and thus regain some trust, courage, and hope. Instead, anger and bitterness added to their injury and exacerbated their suffering. In the 1990s the people of Halabja were outraged about the lack of assistance by both the Kurdish parties and government and the international community. They denounced Western countries' previous complicity with the Iraqi Baath regime and its production of chemical weapons and urgently called upon the international community to engage in the reconstruction of Halabja. They felt betrayed and forgotten once again.[23]

4.3 Changes After 2003

The situation only changed in 2003 with the second U.S.-led invasion of Iraq. In the run-up to the invasion, U.S. president George W. Bush made frequent reference to Saddam Hussein's use of poison gas against his own population. After years of

[21]An overview on the developments and legal aspects of the international "humanitarian intervention" and the establishment of safe havens in Northern Iraq after the Kurdish mass exodus 1991 is given by Cook (1995).

[22]Winter (2002) provides a comprehensive analysis of the provisional situation in Kurdistan-Iraq during the 1990s.

[23]The author's own observations visiting Halabja in the 1990s and talking to survivors.

silencing, the chemical attack against Halabja now became an argument for legitimizing the invasion.[24] This time the military invasion led to the demise of the Baath regime and as such was enthusiastically welcomed and celebrated all over Kurdistan. For the first time after 1988, a sense of safety was restored to the Halabja survivors. The sanctioning of Kurdistan as an autonomous region in a federal state of Iraq by the Iraqi constitution of 2005 brought about a sense of political stability. The main perpetrators—Saddam Hussein and Ali Hassan al-Majid— were sentenced to death by the Iraqi High Tribunal and executed. Al-Majid received four death sentences for crimes against humanity, war crimes, and genocide against the Kurds and was hanged in 2010. Saddam Hussein was already executed on December 30, 2006 for the massacres against Shiites in Dujail before the Anfal and Halabja trials had come to an end.[25] Internationally, there has been a highly controversial debate about the legitimacy of the trials because of the strong U.S. role in the set up of the trials, the victor's justice involved, and the non-compliance with international law standards.[26] However, for the Anfal and Halabja survivors, these trials—the fact that survivors gave testimonies in a court of law facing the main perpetrators—were important milestones for restoring their sense of justice and satisfaction. Yet many survivors were disappointed that Saddam Hussein was not executed for Halabja and Anfal, as they wanted his death to be linked in the historical record to these crimes (Mlodoch 2014, 364–365).

After 2003 the Kurdish region saw a rapid process of economic development and modernization, which brought improvement to the life conditions of the Anfal and Halabja survivors as well. The Kurdistan Regional Government finally started to invest in the destroyed areas' infrastructure. Survivors' pensions were raised; they received grants for building houses and their children stipends for university or college education. Today, the survivors' economic situation has improved. Those who were children during the chemical attacks have meanwhile grown up, started their own families, finished their education, and became a source of pride for the entire survivors' community. Indeed there are strong collective structures and a sense of community among the survivors due to the shared experience. All these changes have at last created the possibility for the survivors to take some rest and engage in the reconstruction of their town and their social structures.

Mamosta Fakhradin, who saw two of his children die in his arms on March 16, 1988, is today a teacher at a primary school in Halabja and says that he regards each of his students as his own child (Hidou 2011). A young man in Ako Sirini's 2013 documentary who was a baby when he lost his parents in the gas attack talks about the day he took his degree at the Medical School. However, he said it was a sad day

[24]See, e.g., George W. Bush's speech at the 2003 Azores Summit in Portugal. President Bush: Monday "Moment of Truth" for World on Iraq. March 16, 2003. http://georgewbush-whitehouse.archives.gov/news/releases/2003/03/20030316-3.html. Accessed March 10, 2016.

[25]For the documentation of the trials see International Center for Transitional Justice (2006a, b).

[26]For an overview on the debate see Mlodoch (2014, 348–358).

for him as he imagined how proud he would have made his parents coming home with the university certificate. He is now practicing medicine in Halabja. The other young man in the film who lost his parents has become an artist. He gives art lectures to young people and says that he wants to bring color back to Halabja. They are examples of how survivors live with haunting memories and indelible images, but at the same time try to relate to the present and engage in reconstructing their lives.

Today Halabja is step by step turning into a lively town again. Streets and markets are crowded; the town has playgrounds, schools, a university, women centers, and cultural projects. The reconstruction of the town of Halabja gives a sense of triumph to survivors over the destructive impact of the poison gas. Yet the scars of the past and its representation are visible everywhere. Besides the huge graveyard for the victims with the endless-looking rows of 5,000 tombstones and the huge central memorial at the outskirts of the town, there are numerous smaller memorials, art pieces and wall inscriptions reminding of the poison gas attack all over the town.

However, there is still an intense feeling of rage and bitterness among Halabja survivors. They feel exploited by the Kurdish national discourse and political elite, who define the chemical attack against Halabja as a national trauma but fall short of addressing the survivors' claims and needs. At the occasion of an official remembrance ceremony at the Halabja anniversary in 2006, survivors turned against the attendant Kurdish politicians and their guests, demanding better services instead of high-profile ceremonies and ultimately set the central Halabja monument ablaze (Hiltermann 2008).[27]

Survivors are also bitter about the lack of international assistance and recognition. They strongly call upon international governments and parliaments to recognize the Anfal and Halabja attacks as genocidal and to take to justice the international companies which delivered supplies for the poison-gas production to Saddam Hussein's regime. Indeed, although UNSCOM inspections and the Baath regime's confiscated documents brought evidence about the implication of European and specifically West German companies in Iraq's poison gas production in the 1980s (Kelly 2013), there has not been to date any noteworthy legal prosecution of those responsible. Only one Dutch businessman, Frans van Anraat, whose company had delivered thousands of tons of chemical substances to the Iraqi regime in the 1980s, has been convicted to 17 years in prison for supporting war crimes by a District Court in The Hague in 2005, but was acquitted of the charge of supporting genocide (Oñate et al. 2007).

[27]See also Robert F. Worth. Kurds Destroy Monument in Rage at Leadership. *New York Times*, March 17, 2006. http://www.nytimes.com/2006/03/17/international/middleeast/17kurds.html?_r. Accessed March 10, 2016.

Fig. 1 On the anniversary of the poison gas attack, activists in Halabja protest against the chemical attack on Ghouta, Syria. March 16, 2015. WADI e.V. https://wadi-online.org/2016/03/16/halabja-day-2016-end-the-impunity/. Accessed June 26, 2017. Photo reproduced with permission from WADI e.V.

5 New Threats, New Fear, and Joint Initiatives of Poison Gas Survivors

After a period of stabilization, the Kurdish people in Iraq are currently facing new threats. In 2014 the terror militia ISIS took control of large parts of Central and Northern Iraq and committed horrendous massacres of especially the Yezidi Kurds. Once again Kurdish *peshmerga* are fighting and dying in combat, this time against ISIS. Once again the region is mired in conflict and violence, which stir up the traumatic memories of the Halabja and Anfal survivors. Over a million people who fled from ISIS terror in the provinces of Mossul and Central Iraq and another 250,000 Syrian Kurds who fled the war in their country currently seek refuge in Kurdistan-Iraq.[28]

Evidence suggests that in August 2013 chemical weapons were used against civilians by the Syrian government of Bashar al-Assad in the Ghouta area of Damascus (UN Mission to Syria 2013). Survivors from Ghouta and survivors from Halabja jointly founded an initiative named "Breathless."[29] On April 22, 2015, the

[28]United Nations High Commissioner for Refugees. Iraq 3RP Summary 2016: Regional Refugee and Resilience Plan. March 3, 2016. https://data2.unhcr.org/en/documents/details/44046. Accessed March 10, 2016.

[29]See https://www.facebook.com/Breathless-830986016974121/.

100th anniversary of the first use of poison gas by the German Army during World War I at Ypres, they came together in parallel commemoration activities in Kurdistan-Iraq and Syria and jointly called upon the international community to curb the use of chemical weapons in warfare, stating: "It takes one second to drop the bomb, but it takes decades to overcome its impact".[30] On the occasion of the anniversary of the chemical attack on Halabja on March 16, 2015, activists in Halabja commemorized the attack on their town in 1988 and at the same time protested against the chemical attacks in Ghouta. They held up signs asking: "After Halabja you said: Never again. After Ghouta you said: Never again. What will you say next time?"(Fig. 1).

References

Ala'Aldeen, Dlawer. 2005. Long term hazards of chemical weapon agents: analysis of soil samples from Kurdistan years after exposure to sulphur, mustard and nerve agents. DlawerNet. http://www.dlawer.net/?q=node/71. Accessed 30 October 2015.

Al-Khalil, Samir. 1989. *The republic of fear: the politics of modern Iraq*. London: Century Hutchinson.

Bruinessen, Martin van. 1989. *Agha, Sheikh und Staat. Politik und Gesellschaft Kurdistans*. Berlin: Edition Parabolis.

Cook, Helena. 1995. *The safe haven in Northern Iraq: International responsibility for Iraqi Kurdistan*. Essex, London: Human Rights Centre and Kurdistan Human Rights Project.

Farouk-Sluglett, Marion, and Peter Sluglett. 1987. *Iraq since 1958: From revolution to dictatorship*. London, New York: Routledge and Kegan Paul.

Gosden, Christine, Derek Gardener, and Mike Amitay. 2001. Effects of Genotoxic Weapons of Mass Destruction on Civilian Populations. In *Disarmament Forum*. Geneva: United Nations Institute for Disarmament Research.

Hiltermann, Joost. 2007. *A poisonous affair: America, Iraq, and the gassing of Halabja*. New York: Cambridge University Press.

Hiltermann, Joost. 2008. Halabja: The Politics of Memory. International Crisis Group. https://www.crisisgroup.org/middle-east-north-africa/gulf-and-arabian-peninsula/iraq/halabja-politics-memory. Accessed 10 March 2016.

Human Rights Watch. 1991. Whatever happened to the Iraqi Kurds? Human Rights Watch Report March 11. https://www.hrw.org/reports/1991/IRAQ913.htm. Accessed 10 March 2016.

Human Rights Watch. 1993. *Genocide in Iraq*. Human Rights Watch: The Anfal Campaign Against the Kurds. New York.

Human Rights Watch. 1994. *Bureaucracy of Repression*. Human Rights Watch: The Iraqi Government in its Own Words. New York.

International Center for Transitional Justice. 2006a. Dujail. Trial and Error. ICJT Briefing Paper, November 2006. https://www.ictj.org/sites/default/files/ICTJ-Iraq-Dujail-Trial-English-2006.pdf. Accessed 10 March 2016.

International Center for Transitional Justice. 2006b. The Anfal Trial and the Iraqi High Tribunal. Update Number 3: The Defence Phase and Closing Stages of the Anfal Trial. https://www.ictj.org/sites/default/files/ICTJ-Iraq-Anfal-Tribunal-2006-English2.pdf. Accessed 10 March 2016.

[30]Open Letter by Survivors of Chemical Attacks from Iraq, Syria, Iran and Kurdistan. "It Takes a Second to Drop a Bomb, But It Takes Decades to Overcome Its Impacts." *Breathless.* April 22, 2015. https://www.facebook.com/Breathless-830986016974121/. Accessed March 10, 2016.

Keilson, Hans. 1979. *Sequentielle Traumatisierung bei Kindern: Deskriptiv-klinische und quantifizierend-statistische follow-up Untersuchung zum Schicksal der jüdischen Kriegswaisen in den Niederlanden*. Stuttgart: Enke.
Kelly, Michael J. 2013. "Never Again"? German Chemical Corporation Complicity in the Kurdish Genocide. *Berkeley Journal of International Law* 31 (2): 348–391.
McDowall, David. 2004. *A modern history of the Kurds*. London: Palgrave Macmillan.
Mlodoch, Karin. 2014. *The limits of trauma discourse: Women Anfal survivors in Kurdistan-Iraq*. Berlin: Klaus Schwarz Verlag.
Oñate, Santiago, Brigitta Exterkate, Lisa Tabassi, and Erwin van der Borght. 2007. Lessons learned: Chemical traders convicted of war crimes. *Hague Justice Journal* 2 (1): 23–42.
United Nations Mission to Investigate Allegations of the Use of Chemical Weapons in the Syrian Arab Republic. 2013. Report on the Alleged Use of Chemical Weapons in the Ghouta Area of Damascus. United Nations, August, 21. https://undocs.org/A/67/997. Accessed 30 October 2015.
United Nations Monitoring, Verification and Inspection Commission (UNMOVIC). 2006. Summary of the Compendium of Iraq's Proscribed Weapons Programme in the Chemical, Biological and Missile Areas. United Nations. http://www.un.org/Depts/unmovic/new/documents/compendium_summary/s-2006-420-English.pdf. Accessed 30 October 2015.
Vanly, I. Cherif. 1986. *Kurdistan und die Kurden,* vol. 2: *Türkei und Irak—Fortsetzung*. Göttingen: progrom-Reihe Bedrohte Völker.
Winter, Bernhard. 2002. *Kurdistan-Irak: Untergehen im sicheren Hafen*. VAS: Studie über die Folgen einer humanitären Intervention. Frankfurt am Main.

Films

Hidou, Akram. 2011. *Halabja: The lost children*. Kurdistan-Iraq/Germany: Akram Hidou.
Karimi, Taha. 2013. *1001 Apples*. Kurdistan-Iraq: Ava Media/Taha Karimi.
Sirini, Ako. 2013. *There is hope behind the tears*. Kurdistan-Iraq: Ministry of Martyrs and Anfal Affairs.

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The Use of Chemical Weapons in Syria: Implications and Consequences

Ralf Trapp

Abstract Chemical weapons are banned under customary international law, the 1925 Geneva Protocol and the 1997 Chemical Weapons Convention (CWC). The CWC today has achieved near universal adherence; a small number of states, however, remain outside its realm. Syria—until 2013 one of them—was long presumed to possess chemical weapons and in 2012 effectively admitted so. The Syrian civil war always carried the risk that one side or another would use these weapons. Reports to this end began to appear in 2012. In March 2013, following separate requests by Syria and several Western States, the UN Secretary-General began to investigate these allegations. Whilst the investigation team was in Damascus, a large-scale sarin attack was launched on Ghouta, killing hundreds of people. This incident and its subsequent confirmation by the UN team set in motion a series of unprecedented events leading to the elimination of Syria's chemical weapons stockpile under strict international control, supported by financial and in-kind assistance by more than 20 countries. But this multilateral effort did not end the use of toxic chemicals in Syria, and OPCW fact-finding missions have since confirmed several cases of chlorine attacks. Also, ISIS/Daesh reportedly has used chemical weapons including chlorine and mustard gas in Syria and Iraq. The paper concludes that it will be important to identify the perpetrators of these attacks and bring them to justice in order to protect the international norm against poison gas.

1 Introduction

On April 29, 1997, after two decades of negotiations in the Geneva Conference on Disarmament and another four years of work of the Preparatory Commission in The Hague, the Chemical Weapons Convention (CWC) entered into force. As of the

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summer of 2015, this global disarmament treaty, which aims at abolishing once and for all the threat of chemical warfare, had attracted 191 states as its parties.[1] Near universal adherence to this comprehensive ban combines with efforts of the States Parties to internalize its prohibitions and set them firmly into their domestic legislation, penal codes and administrative and enforcement systems. The chemical weapons arsenals and production facilities of the vast majority of countries are under the control of the Convention's treaty organization—the Organization for the Prohibition of Chemical Weapons (OPCW)—and measures to eliminate them are nearing completion. An effective verification system with on-site inspections has been established to verify declarations by the States Parties, ensure that all declared chemical weapons and production facilities are being destroyed, and that no new chemical weapons are produced. To many observers, it appeared that the menace of chemical warfare had become a matter of the past.

But whilst chemical weapons were successfully being taken out of the armory of the majority of countries that had acquired them in the past, a small number of countries remained outside the realm of the CWC.[2] Some of them are presumed to have chemical weapons in their arsenals. The dangers that emanate from the continuing presence of chemical weapons in military arsenals became apparent when Syria spiraled into civil war after the "Arab Spring".

2 Early Reports of Chemical Weapons Use in the Syrian Civil War

In July 2012, a spokesperson of the Syrian Foreign Ministry effectively admitted that Syria possessed chemical weapons; he went on to say that Syria would not use these weapons except against an external aggression (MacFarquhar and Schmitt 2012). Around the same time, reports appeared that claimed that terrorist groups were smuggling chemical weapons from Libya and other countries via Turkey into Syria. Beginning in late 2012, reports emerged on the Internet and in the media alleging the use of chemical weapons in Syria by government forces. At the same time, government sources in Syria claimed that terrorist groups were using improvised chemical weapons.

Whilst the Independent Commission of Inquiry into Syria of the UN Human Rights Council in February 2013 still concluded that there was no credible evidence for the use of chemical weapons by either side (UNGA 2013), allegations and counter-allegations of such uses were increasingly leveled against the Syrian government but also against certain factions of the military opposition, including elements of the Free Syrian Army and groups such as *Jabhat al Nusra*. Then, in

[1]For status updates, see http://www.opcw.org/about-opcw/member-states/status-of-participation/.

[2]As of October 2015, Israel—a signatory state—has yet to ratify its signature, and Egypt, South Sudan, and North Korea have yet to accede to the Convention.

March of 2013, the UN Secretary-General received a request from the government of Syria to investigate an alleged chemical weapons attack against government troops and civilians in Khan Al Asal near Aleppo.[3]

According to the Syrian report, 25 people had died and more than 110 civilians and soldiers been injured as the result of an attack with what was said to have been a chemical rocket. The Syrian government accused the opposition of being responsible for the chemical attack whilst an opposition military spokesperson blamed government troops for it. Subsequently, France and the United Kingdom reported allegations of the use of chemical weapons in several locations in Syria, including in Khan Al Asal and near Damascus, Aleppo, and Homs, near the Turkish border, and in other places, blaming the Syrian regime as the instigator (UNODA 2013, 2). They requested that the UN investigation be mandated to investigate all these alleged incidents. The United States, who had initially been cautious about confirming any chemical weapons use by either side, eventually also concluded that the government of Syria had used chemical weapons in several instances (ibid., 3–4).

3 The Secretary-General's Investigation

In response to these requests, the UN Secretary-General established an investigation mission under the leadership of Swedish scientist Åke Sellström, using a mechanism that had been devised during the Cold War as a tool to investigate alleged breaches of the 1925 Geneva Protocol (Ban 2013a). The mission was composed of a group of inspectors of the OPCW, medical experts of the WHO, and supported by UN staff in New York as well as Syria and the region. But Sellström's team was for several months unable to go into Syria, whilst in New York negotiations continued behind closed doors about which specific incidents and locations the team would be allowed to scrutinize.

All along, however, video footage and photographic images spread through social media and the Internet, showing what appeared to be further victims of poison gas attacks. There also were reports from journalists who had managed to gain access to activists in Syria or who had in fact spent time with one or another group of fighters, and who had collected information about the alleged chemical weapons attacks. Several States extended their own intelligence gathering operations in Syria. Russia, France, the United Kingdom, and the United States all acquired samples from different sources and locations of alleged gas attacks, and analyzed them for the presence of chemical agents. They concurred that their analysis showed that the nerve agent sarin had been used. But whilst Russia concluded that terrorist groups fighting for the opposition had used the nerve agent,

[3]For a chronology of the allegations and the steps taken by Secretary-General and his investigation team, see the Final Investigation Report (UNODA 2013).

Western countries concluded that it had been the Assad regime who was responsible for the gas attacks (Robinson 2013, 28–34; Gladstone 2013).

Any use of chemical weapons would, of course, constitute a war crime. Not only have chemical weapons been banned by the 1925 Geneva Protocol and the 1997 Chemical Weapons Convention, but there is also a common view that under customary international law, any use of a chemical weapon in armed conflict would constitute a prohibited act (ICRC 2005). Amongst the many atrocities committed in the Syrian civil war, and meticulously recorded by the Independent Commission of Inquiry into Syria of the Human Rights Council, the use of chemical weapons was specifically noted as an act that is prohibited in all circumstances under customary international humanitarian law, and a war crime under the Rome Statute (UNGA 2013).

But the situation remained unclear for some time. Sellström's investigation team could not get into Syria, and much of the information could not be independently verified. Videos and images posted on the Internet did not allow an unequivocal confirmation that sarin had in fact been used; the authenticity of the samples analyzed by the different countries could not be demonstrated independently; videos and photographs on the Internet appeared to show both Syrian army and opposition fighters preparing and firing what were described to be chemical rockets; and, unsurprisingly, the propaganda war surrounding the allegations and the debate about how the international community should respond increased in intensity, obscuring both the facts of the matter and the underlying intentions of the different actors involved. The stakes were high, framed by fears about possible military strikes on the one side and hopes for military intervention and support on the other.

After several months of negotiations between the UN and Syria about which particular locations the team would be allowed to access and investigate, the UN Secretary General's investigation mission was finally dispatched to Damascus in the middle of August 2013. Whilst the team was making final preparations for its fieldwork at its operations base in Damascus, in the night of August 21, 2013, a major gas attack was launched against civilian quarters in Ghouta, a suburb just outside of Damascus. Within hours, videos posted on the Internet showed large numbers of victims arriving in hospitals for treatment of what clearly were poison gas injuries, among them many women and children. The precise number of casualties has never been established and would be difficult if not impossible to verify—casualty figures ranged from 355 to more than 1500 people killed plus many more injured—but there was little doubt that a war gas had been used (France 2013; United States 2013).

What followed had no precedence in the history of chemical weapons disarmament. First, within days, despite the on-going civil war and in fact despite having been attacked by sniper fire on one occasion, the UN investigation team negotiated its way into the attacked sites and carried out as thorough an investigation as was possible under the conditions of the civil war. In the compressed time available, the team interviewed a significant number of victims of the attack, medically examined many of them and took blood samples for subsequent analysis. It also inspected several of the impact sites and conducted interviews with eye witnesses, assessed the remnants of the weapons used, estimated likely flight trajectories, and took samples from impact craters and from the weapons themselves (UN Mission 2013, p. 4 and appendices 5 and 6). Subsequent analysis of these biomedical and environmental samples undertaken by OPCW designated laboratories confirmed beyond doubt that sarin had been used, in significant amounts, in the attack on Ghouta.

The Sellström team subsequently also investigated other incidents of alleged chemical attacks in Syria and was able, with varying degrees of certainty, to confirm that sarin had been used in a number of cases (UNODA 2013, 19–21). The incidents for which the use of the nerve agent was confirmed included both scenarios where Syrian government forces were accused of having used chemical weapons and scenarios where the opposition had been accused of having done so. The UN team was not mandated, however, to establish which party had used the chemical weapon. In fact, such an attribution would have required a different type of investigation, and access rights as well as investigative tools reaching beyond what the team could bring to bear under the circumstances and the scope of the UN Secretary-General mechanism (for example, reference data with the precise analytical signatures of the chemical agent mixtures present in the Syrian CW stockpile and access to documents and individuals in the military command structures of the parties involved in the incidents).

4 The Elimination of the Syrian Chemical Weapons Program

As political pressure mounted after the confirmation of the use of sarin in Ghouta, and the risk of external military intervention increased, a second remarkable development took place: a last-minute agreement was reached in Geneva between the Russian Federation and the United States of America about a framework for the elimination of Syria's chemical weapons program (OPCW 2013a), combined with Syria's accession to the Chemical Weapons Convention on September 13, 2013 and its declaration that it would apply the Convention's norms and obligations immediately, even before becoming a State Party.

Within a mere two weeks, the OPCW Executive Council transferred this general framework agreement into detailed modalities for the disablement and destruction of the Syrian chemical weapons arsenal and production capacity (OPCW 2013b).[4] On the very same day, resolution 2118 (2013) of the UN Security Council

[4]Syria joined the CWC after the expiration of the ten-year destruction period prescribed under Article IV(6) of the CWC for the complete elimination of CW stockpiles (which expired April 29, 2007). In such a situation, the OPCW Executive Council under Article IV(8) of the CWC establishes the destruction deadlines and related verification measures for the newcomer State Party. This enabled the conversion of the bilateral US-Russian framework into a legally binding undertaking under the CWC without a formal amendment of the CWC.

harnessed this decision and added the strength of the UN Charter to this endeavor.[5] Within days, OPCW inspectors began inspecting the Syrian chemical weapons facilities to confirm weapons and equipment inventories, advise Syria on how to apply the requirements of the CWC, and start preparations for the destruction and removal operations envisaged. In October, a Joint Mission of the United Nations and the OPCW was established to implement and supervise the chemical weapons disarmament of Syria, led by Sigrid Kaag.

Syria declared a total of 41 CW stockpile and production facilities at 23 locations (OPCW 2013c). 18 of them were CW production facilities, 12 were storage facilities, and there were 8 mobile filling units and 3 other CW-related facilities. The declared stockpile amounted to 1000 tons of category-1 chemicals (these are chemicals listed in Schedule 1 of the CWC and included the sarin key precursor DF, a key precursor for VX, and mustard gas). There also were some 290 tons of other chemicals that formed part of the CW stockpile, 1230 items of unfilled munitions, and 2 cylinders which the Syrian government claimed did not belong to it but might contain chemical agent.

By the beginning of November, the initial inspections of the Syrian chemical weapons stocks and production facilities had been completed (OPCW 2013c). Some sites could only be inspected by authenticated video links but these turned out to be empty. The vast majority of the declared stockpile and production locations were inspected by OPCW inspectors, and their inventories of weapons, materials, and specialized production and filling equipment verified and secured. The stationary and mobile production and mixing units were functionally disabled: they were physically damaged so that they could no longer be used for their intended purpose. That was important because the deployment system that the Syrian army had developed for its main chemical weapon—the nerve agent sarin—depended on mixing two precursor materials (DF and iso-Propanol) and an acid scavenger (hexamethylene tetramine) to form sarin shortly before the weapons were deployed and used. Once the mixing and filling equipment had been rendered inoperable under the watchful eyes of the inspectors, that deployment system could no longer be employed and the Syrian army had lost its means of delivering sarin effectively, even though it still had access to the precursor and other chemicals it would need to make sarin.

The preparations for the transportation of most of the chemical materials of Syria's stockpile out of the country began immediately after the initial inspection campaign was completed, supported by an Operations Planning Group established by the OPCW to coordinate the support of Member States and the Joint Mission (OPCW 2013d) for the removal and destruction operation. This removal and the decision to destroy the chemical weapons materials outside of Syrian territory were two of several modifications to the rules of the CWC that became necessary under the special circumstances of Syria (Trapp 2014a). The sequence of this operation

[5]This resolution also removed any possible doubts about the legal power of some of the elements of the Executive Council decision, given the effect of Article 103 of the UN Charter.

followed a simple logic: to prevent any further use of these chemical weapons, one had to immediately disable the system for delivering the chemical agents, then remove as soon as possible all chemical weapons materials that would have required dedicated destruction facilities—which did not exist—from Syrian soil, destroy the remaining material (Isopropanol) in Syria, and then destroy the materials removed from Syria as soon as practicable. At the same time, these measures had to prevent any new production of chemical weapons, and get the weapons, materials and specialized equipment away from anyone who might want to lay their hands on them to use them.

This approach involved adapting some of the legal and regulatory provisions of the Chemical Weapons Convention and its verification procedures to the special situation in Syria (Krutzsch et al. 2014). That in itself was a novelty in the way the OPCW implemented the CWC. States Parties are usually reluctant to change treaty provisions, in particular when it comes to arms control and security agreements. But special circumstances warranted special measures and the political will to tweak the provisions of the treaty and make them work under these unusual conditions did prevail over the usual caution states exercise in treaty interpretation.

Equally important, the elimination of Syria's chemical weapons program under the conditions of an on-going civil war required a high degree of international cooperation and support for what turned into a complex multilateral overland and maritime operation. The removal operation was supported by countries as diverse as Denmark, Norway, the UK, Germany, China, Russia, and the USA, coordinated with the help of the Joint OPCW-UN Mission and special task forces set up for the different aspects of the operation (OPCW 2014a). The Mediterranean Seaport of Latakia was selected as the exit point for removing the weapons materials from Syria. The chemical weapons materials were packed in ISO transport containers and moved by road to Latakia in several shipments, beginning in January 2014. The last shipment arrived in Latakia in June 2014, some six months later than originally planned; but given the circumstances, this was a remarkable achievement.

Upon arrival of each shipment at the port of Latakia, the containers were loaded onto transport ships provided by Denmark and Norway. These transport ships did not permanently dock in Latakia but remained at sea or in Cyprus most of the time, protected by a multilateral contingent of navy ships from a number of countries including China and Russia. Once the removal operation was completed (on June 23, 2014), the transport ships sailed under escort to the Italian container port of Gioia Tauro where the most dangerous materials (sulfur mustard and DF) were reloaded onto the US maritime vessel Cape Ray. The remaining materials were shipped to facilities in the US, the UK and Finland. The effluents from the destruction aboard the Cape Ray would eventually be shipped to facilities in Germany and Finland for final treatment.

5 Chemical Weapons Destruction at Sea

A critical step was the destruction of the sarin precursor DF and the mustard gas. Well before Syria's accession to the CWC, at the beginning of 2013, the United States had commissioned the development of a field-deployable CW destruction facility that could be airlifted to wherever it was to be deployed, and after a 10-day set-up period could operate independently of any local supplies and destroy chemical agents and precursors by chemical hydrolysis (CBARR 2013). The system was called the "Field Deployable Hydrolysis System" or FDHS. The design capacity of the system would allow it to destroy, under normal operating conditions, the entire Syrian stockpile in approximately 30 days.

The original plan had been to find a country in the neighborhood of Syria that would be willing to host the mobile destruction facility (or to offer one of its destruction facilities if it had one) to destroy the Syrian chemical materials. But a combination of regulatory, political, and technical factors worked against this plan, and no country could be found to take on the destruction task or host the US facility. As time progressed it became clear that a more unconventional approach was needed to eliminate Syria's chemical weapons materials in the agreed timeframe.

In November 2013, it became clear that the only remaining option to eliminate the Syrian CW stockpile outside of Syria would be to destroy the most dangerous chemical materials at sea (OPCW 2013e). The US began to reconfigure its field-deployable hydrolysis facility so it could be set up inside a Navy Reserve container ship, the Cape Ray. A chemical operation that would under normal conditions have been set up on land on an area the size of several football fields now had to be stacked into the three dimensions of a container ship.

The destruction of chemical weapons on a floating platform is not in itself a new concept, but the technical difficulties that needed to be overcome for operating a chemical destruction plant at high sea were nevertheless significant. Here are some of the issues that needed to be considered and resolved before destruction operations could begin in earnest (Trapp 2014b):

- Safety: the need to protect sailors, workers, and OPCW inspectors on board as well as the environment, in case of any spills or accidents, was paramount. Many of the procedures for operating the destruction plant and for responding to incidents needed to be adapted to the compact and at the same time three-dimensional work environment on board the Cape Ray. It also required very careful planning of how the different types of containers had to be loaded, to determine which containers went onto which deck and place within a deck in order to minimize the need to move containers with highly toxic chemicals between or across decks, and to facilitate the way in which the containers' content could be piped to bring the toxic/precursor chemicals and the reaction water and caustics needed for the hydrolysis to the plant, and for back-loading the reaction masses into empty containers. The operation was to be essentially self-contained, that is to say, all chemicals needed for the plant operation were

on board; no additional materials should be brought on board whilst the facility was in operation; and no reaction masses were to be taken off the ship until the destruction operation was completed.
- The operational environment: normally, a chemical plant operation requires a stable platform to work on, but a ship at sea moves with and within the environment; it was important to establish under which sea condition the facility could be operated safely, and under which it needed to be shut down. Also, the pace with which the facility was being operated needed to be adjusted to the environmental conditions, and operations had to be phased in gradually to make sure the operators had full control over the process and equipment. A significant amount of sea training with the facility operating in simulation mode was undertaken before actual destruction operations could begin.
- Environmental protection: the need to prevent any leaks and accidental releases of the precursor materials and agents as well as of the reaction masses into the environment. This was a particular concern given the vulnerability of the maritime environment in the Mediterranean Sea, and quickly became a political issue in many of the countries with coastlines in the Mediterranean Sea (Walker et al. 2014; Üzümcü 2014).
- Verifiability: despite the unusual environment, the destruction operation had to be undertaken in a way that was consistent with the requirements of the CWC, in particular with regard to the systematic monitoring of all destruction operations by OPCW inspectors to ensure full accountability and to confirm that all chemical weapons materials that had been removed from Syria were in fact destroyed.

Despite these complexities, the destruction at sea proceeded without incidents. It began in late June 2014, and on August 18, 2014, Secretary of State John Kerry confirmed that 100% of DF (methylphosphonyl difluoride), the precursor for sarin nerve agent, as well as 20 tons of mustard gas had been destroyed aboard the Cape Ray (Kerry 2014). The reaction masses were shipped to facilities in Germany and Finland for final disposal by incineration.

The importance of this collective effort to eliminate the Syrian chemical weapons arsenal cannot be overstated. It was a complex multilateral operation implemented by the OPCW, verified by its inspectors, and supported by financial and in-kind contributions from 21 different countries and the European Union. A total of 10 countries supported the operation with a range of assets and practical support measures, ranging from the delivery of transportation containers to the provision of security and naval support, making available port facilities, and undertaking actual destruction operations of the declared chemical agents and precursors as well as of other chemicals and the reaction masses of the primary destruction operation on board the Cape Ray.

This complex and truly collaborative effort took a stockpile of extremely dangerous and effective chemical weapons out of the context of a horrendous civil war that has in the meantime spread well beyond Syria's borders and become a regional insurgency with global ramifications. Work on completing the destruction of the

Syrian CW production facilities has yet to be completed but is well under way. The OPCW will continue to verify that the production of chemical weapons in Syria will not be resumed.

6 New Incidents of Chemical Weapons Uses

But chemical weapons disarmament cannot remove all toxic chemicals from a country. Many materials that are in daily use in society are poisonous and could be used in improvised chemical weapons. We have today confirmation that improvised chemical weapons in the form of chlorine-filled barrel bombs are being used in Syria (OPCW 2014b). The OPCW has undertaken several fact-finding missions and has on a number of occasions confirmed with a high degree of confidence that chlorine has been employed as a means of war fighting in Syria (OPCW 2015). There is also no doubt that “Daesh” and groups associated with it have shown an interest in acquiring chemical weapons, and reports—yet to be independently verified—suggest that Daesh may have used mustard gas against Kurdish fighters in Iraq (Associated Press 2015).

The OPCW’s Executive Council as well as the UN Security Council have condemned the use of chlorine in the Syrian armed conflict, and further investigations are being conducted by the OPCW Fact-Finding Mission and the OPCW-UN Joint Investigation Mechanism to establish what actually happened. Does this imply that, as a consequence of the recent uses of toxic chemicals in the Syrian conflict, the threshold against the use of toxic chemicals in armed conflict has in fact been lowered? Statements by political leaders and international bodies including the Security Council and the OPCW seem to point in the opposite direction; to use Ban Ki Moon’s words: “the use of chemical weapons by any side under any circumstances would constitute an outrageous crime with dire consequences, and a crime against humanity” (Ban 2013b). But to prevent a lowering of the threshold for the use of chemical weapons, it will be important to bring those responsible for the use of chemical weapons in Syria to justice.

7 Attribution and Accountability

Issues of attribution and accountability were not taken up by the investigations under the UN Secretary-General Mechanism (UN-SGM). Investigating culpability would have required a type of investigation different from what the SGM is: a science-based fact finding mission. This is not to say that science cannot help in identifying the responsible individuals who ordered the use of sarin, but a fact-finding mission conducted at the sites of the alleged chemical weapons use and hosted by the Syrian government differs in certain respects from a criminal investigation.

There are, however, other international mechanisms such as the Human Rights Council's Independent Commission of Inquiry for Syria or the International Criminal Court (ICC), which could be used to investigate issues related to attribution and accountability. Whilst the Syria Commission has been actively collecting and securing evidence with regard to alleged human rights violations, by all parties involved in the Syrian conflict, the ICC has not been activated. Any use of chemical weapons in armed conflict would fall under its jurisdiction under the Rome Statutes as amended in Cartagena; but as Syria is not a member of the ICC, this would have required an express authorization by the Security Council.

However, the Security Council did not make use of this mechanism but instead decided to establish a separate, dedicated investigation mechanism: a Joint Investigation Mechanism of the UN Secretary-General in close coordination with the OPCW (UN 2015). It is too early to comment on how effective this mechanism will be, but past experience strongly suggests that it will only yield results if the Security Council remains united in its support of the work of the Joint Investigation Mission, and can avoid the politicization of issues related to its mandate, scope and the nature of the investigation.

8 Conclusions

Many lessons have been learnt and are still being learnt in the process of eliminating the chemical weapons program of Syria. Some issues that are being pursued already by the United Nations, the OPCW, the WHO, and other relevant actors include:

- Further strengthen the authority and operational capacity of the UN Secretary-General Mechanism to investigate allegations of the use of chemical and biological weapons
- Organize effective interagency cooperation to implement complex and demanding operations in dangerous and potentially hostile environments
- Appreciate the role that disarmament and arms control can play (but also their limitations) in extreme circumstances including during armed conflict
- Preserve and strengthen the ways in which effective multilateral collaboration can be orchestrated despite existing disagreements on a number of key policy and security issues.

References

Associated Press. 2015. German intelligence confirms Isis used mustard gas in Iraq, says news report. *The Guardian*, September 8. http://www.theguardian.com/world/2015/sep/08/german-intelligence-confirms-isis-used-mustard-gas-in-iraq-says-news-report. Accessed 27 Oct 2015.

Ban Ki-moon. 2013a. Secretary-general's press encounter on Syrian government request. New York, March 21. http://www.un.org/sg/offthecuff/index.asp?nid=2745. Accessed 27 Oct 2015.

Ban Ki-moon. 2013b. Secretary-General's remarks to the third review conference of the states parties to the Chemical Weapons Convention. *The Hague*, April 8, http://www.un.org/sg/statements/index.asp?nid=6722 . Accessed 27 Oct 2015.

Chemical, Biological, Application and Risk Reduction Business Unit (CBARR). 2013. The field deployable hydrolysis system. *CBARR News* 1.8 Special Edition. http://www.ecbc.army.mil/cbarr/newsletter/2013/CBARR_August2013.pdf. Accessed 29 Sept 2016.

France. 2013. Syria/Syrian Chemical Programme—National executive summary of declassified intelligence. Paris, September 3. http://www.diplomatie.gouv.fr/en/IMG/pdf/Syrian_Chemical_Programme.pdf . Accessed 27 Oct 2015.

Gladstone, Rick. 2013. Russia says study suggests Syria rebels used sarin. *The New York Times*, July 9. http://www.nytimes.com/2013/07/10/world/middleeast/russia-says-study-suggests-syria-rebels-used-sarin.html. Accessed 27 Oct 2015.

ICRC. 2005. Customary law. *International Review of the Red Cross* 87.857, Rule 74.

Kerry, John. 2014. *Milestone in Eliminating Syria's Chemical Weapons Programme.* Press Statement, August 18. www.state.gov. Accessed 27 Oct 2015.

Krutzsch, Walter, Eric Myjer, and Ralf Trapp. 2014. Part Six. Annex to the commentary: Issues raised by the accession of Syria to the chemical weapons convention. *The chemical weapons convention: A commentary,* eds. Walter Krutzsch, Eric Myjer, and Ralf Trapp, 689–701. Oxford: Oxford University Press.

MacFarquhar, Neil, and Eric Schmitt. 2012. Syria threatens chemical attack on foreign forces. *The New York Times,* July 23. http://www.nytimes.com/2012/07/24/world/middleeast/chemical-weapons-wont-be-used-in-rebellion-syria-says.html. Accessed 27 Oct 2015.

OPCW 2013a. Russian Federation and the United States of America. *Framework for Elimination of Syrian Chemical Weapons.* Executive Council document EC-M-33/Nat.1, September 17.

OPCW 2013b. *Destruction of Syrian Chemical Weapons*. Executive Council Decision EC-M-33/Dec.1, September 27. https://www.opcw.org/?id=1902. Accessed 27 Oct 2015.

OPCW 2013c. *Progress in the Elimination of the Syrian Chemical Weapons Programme*. Note by the Director-General, Executive Council document EC-M-34/DG.01, October 25.

OPCW 2013d. *Progress in the Elimination of the Syrian Chemical Weapons Programme*. Note by the Director-General, Executive Council document EC-M-35/DG.01, November 25.

OPCW 2013e. *Progress in the Elimination of the Syrian Chemical Weapons Programme*. Note by the Director-General, Executive Council document EC-M-36/DG.01, December 2.

OPCW 2014a. *Progress in the Elimination of the Syrian Chemical Weapons Programme*. Note by the Director-General, Executive Council document EC-M-44/DG.02, August 25.

OPCW 2014b. *OPCW Fact Finding Mission: "Compelling Confirmation" That Chlorine Gas Used as Weapon in Syria.* Press Release, September 10. https://www.opcw.org/news/article/opcw-fact-finding-mission-compelling-confirmation-that-chlorine-gas-used-as-weapon-in-syria/. Accessed 27 Oct 2015.

OPCW 2015. *Allegations of Toxic Chemical Attacks in Syria.* Press Release, March 25. https://www.opcw.org/news/article/allegations-of-toxic-chemical-attacks-in-syria/. Accessed 27 Oct 2015.

Robinson, Julian Perry. 2013. *Alleged Use of Chemical Weapons in Syria*. Harvard Sussex Project Occasional Paper 4. http://www.sussex.ac.uk/Units/spru/hsp/occasional%20papers/HSPOP_4.pdf. Accessed 29 Sept 2016.

Trapp, Ralf. 2014a. Elimination of the chemical weapons stockpile of Syria. *Journal of Conflict and Security Law* 19 (1): 7–23.

Trapp, Ralf. 2014b. *The Elimination of State Chemical Weapons Programmes: Past Experiences and Current Challenges.* Paper presented at the 4th International Conference on Industrial and Hazardous Waste Management, September 2–4. Chania (Crete), Greece.

UNGA. 2013. United Nations General Assembly Document A/HRC/23/58, July 18, 2013. Paragraph 136. https://documents-dds-ny.un.org/doc/UNDOC/GEN/G13/156/20/PDF/G1315620.pdf?OpenElement. Accessed 27 Oct 2015.

UN Mission. 2013. United Nations Mission to investigate allegations of the use of chemical weapons in the Syrian Arab Republic. Report on the alleged use of chemical weapons in the Ghouta Area of Damascus on 21 August 2013. http://www.un.org/zh/focus/northafrica/cwinvestigation.pdf. Accessed 27 Oct 2015.

UNODA. 2013. United Nations Office of Disarmament Affairs. Final Report of the United Nations Mission to investigate allegations of the use of chemical weapons in the Syrian Arab Republic. https://unoda-web.s3.amazonaws.com/wp-content/uploads/2013/12/report.pdf. Accessed 27 Oct 2015.

UN. 2015. Security Council Unanimously Adopts Resolution 2235 (2015), establishing mechanism to identify perpetrators using chemical weapons in Syria. Security Council meetings coverage. http://www.un.org/press/en/2015/sc12001.doc.htm. Accessed 27 Oct 2015.

United States, 2013. U.S. Government Assessment of the Syrian Government's Use of chemical weapons on August 21, 2013. https://www.whitehouse.gov/the-press-office/2013/08/30/government-assessment-syrian-government-s-use-chemical-weapons-august-21. Accessed 27 Oct 2015.

Üzümcü, Ahmet. 2014. Letter of OPCW Director-General to the Pancretan Commission Against the Destruction of Syrian Chemical Weapons in the Enclosed Sea of the Mediterranean Sea. July 29, 2014. https://www.opcw.org/fileadmin/OPCW/ODG/uzumcu/DG_Letter_Pancretan_Commission.pdf. Accessed 27 Oct 2015.

Walker, Paul, et al. 2014. Open Letter to Secretaries John Kerry and Chuck Hagel: public outreach and stakeholder involvement in destruction of Syrian chemical weapons. http://www.the-trench.org/open-letter/. Accessed 27 Oct 2015.

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Part IV
Commemoration Ceremony

A Century of Chemical Warfare: Building a World Free of Chemical Weapons

Paul F. Walker

Abstract The first major use of chemical weapons in warfare was on April 22, 1915, when Germany attacked Allied forces along the Ypres Salient in Belgium in World War I. Since that historic attack a century ago, dozens of countries have researched, developed, tested, and deployed still more deadly chemical weapons. These inhumane and indiscriminate weapons of mass destruction were again used in 1924 by Spain against Morocco, by Italy against Libya and Ethiopia in the 1920s and 1930s, and by Japan against China in World War II (Robinson 1971). More recently they were deployed by Iraq against Iran and Iraq's Kurdish population in the 1980s, and from 2012 to the present in the Syrian civil war. The 1993 Chemical Weapons Convention (CWC) in 2016 includes 192 countries, 98% of the world's population, with only four countries—Egypt, Israel, North Korea, and South Sudan—still missing. And of the 72,525 metric tons of chemical agents declared to date in eight possessor states, over 66,000 metric tons—92%—have been safely destroyed in the last 25 years. This is a historic achievement in global disarmament and peace-building and needs to continue until we rid the world of all chemical weapons, prevent their re-emergence, and promote peaceful uses of chemistry.

1 Introduction

Chemicals have been used as weapons for centuries, primarily in poison arrows and darts and in targeted assassination attempts. But just a century ago, on April 22, 1915, a chemical, in this case chlorine, was used on a massive scale in major warfare. The advance of the German 4th Army against Ypres, Belgium, in November 1914 had been stalemated for months by British, French, Belgian, Canadian, Algerian, Senegalese, and other Allied forces which were dug into trenches along the Ypres Salient in World War I. At 5 o'clock in the afternoon of April 22, when the wind had finally turned to blow from the northeast, German

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