TWO EARLY ARABIC SOURCES ON THE MAGNETIC COMPASS

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In this paper two previously unpublished texts on the magnetic compass from the medieval Islamic world will be discussed, the first by the Yemeni Sultan al-Ashraf (ca. 1290) and the second by the Cairene astronomer Ibn Sim^{c}ūn (ca. 1300). These two treatises constitute the earliest known evidence attesting the use of the magnetic compass for the determination of the qibla, the sacred direction of Islam. A brief introduction glimpses at the history of the magnetic compass in Europe and China and mentions previously known early Arabic sources on the instrument and its use. This is followed by some remarks on the authors and the manuscripts, the Arabic texts with English translations, and comments on problems encountered while working on the texts.

1. Survey of the history of the magnetic compass

The Yemeni astronomer-prince al-Ashraf (ca. 1290) and (apparently) also a Cairene astronomer called Ibn Sim^{c}ūn (ca. 1300)[1] both wrote treatises on the magnetic compass. These two previously unpublished texts will be presented in this paper, prefaced by a brief survey of the knowledge on and use of the magnetic compass in the European and Islamic Middle Ages in order to put these new sources in the context of previous knowledge on the subject.

Although the magnet and its attractive property were known in Antiquity, there is no mention of its directive potential in the sources.[2] In the late nine-

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[1] Prof. David A. King informs me that the author is probably an Egyptian astronomer and muezzin called Ibn Sim^{c}ūn; see further King, article "Ṭāsa" in *EI*^{2}*;* Suter, "Mathematiker und Astronomen," 1900, p. 162, no. 398; King, *Survey,* 1986, p. 60, no. C24; King, "On the Role of the Muezzin and the *Muwaqqit,"* 1996, pp. 298f. (Since the present article was completed there has appeared in King, *World-Maps,* 1999, a facsimile of Ibn Sim^{c}ūn's treatise [p. 113] as well as fol. 145v of al-Ashraf's treatise, with the diagram [p. 111].) The research for this article was supported by a grant from the Hans A. Jenemann-Stiftung (Gesellschaft Deutscher Chemiker).

[2] See Rommel, article "Magnet" in Pauly; Radl, *Magnetstein in der Antike,* 1988;

teenth and early twentieth century the so-called "south-pointing chariot" was understood as an early indication of the use of the magnetic compass in China, but it seems to have been a mechanical device to maintain a specific direction, for the earliest reference to the magnetic compass in China dates from the eleventh century.[3] The first known written reference to a magnetic compass in the Occident dates back to the year 1187, when Alexander Neckam reported the use of a magnetic compass for the region of the English Channel.[4] In 1269 Petrus Peregrinus of Maricourt, in his well-known *Epistola de magnete,* described a floating compass for astronomical purposes as well as a dry compass for seafaring.[5] For the former instrument a magnetic

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Balmer, *Geschichte des Erdmagnetismus,* 1956, pp. 47ff.; Klaproth, *Lettre,* 1834, pp. 9f. Hackmann, "Stradanus," 1994, p. 158, mentions a section in Pliny which he interprets as a hint at the knowledge of the directive power of the magnet.

[3] On the south-pointing chariot as a magnetic compass see, for example, Klaproth, *Lettre,* 1834. Mitchell, *Terrestrial Magnetism and Atmospherical Electricity* 37, 1932, pp. 105ff., gives a survey of authors advocating this opinion. On the correction showing the south-pointing chariot to be a mechanical device and the earliest established proof see Hashimoto, *Memoirs of the Research Department of Toyo Bunko* 1, 1926; Needham, *Scientia* 55:7, 1961, pp. 225ff.; Needham, *Science and Civilisation,* 1954–1986, 4:2, pp. 286ff. (south-pointing chariot), 3, pp. 310ff. (compass-sundials), 4:3, pp. 562ff. (use of the magnetic compass for navigation), 4:1, pp. 229ff. (magnetism, magnetic stones and their use).

[4] The magnetic needle is mentioned in his *De utensilibus*, and further in his *De naturis rerum*, probably written at the end of the twelfth century (see Sarton, *Introduction,* 1927–1948, 2, pp. 385f.; Mitchell, *Terrestrial Magnetism and Atmospherical Electricity* 37, 1932, p. 125, and Bromehead, *Terrestrial Magnetism and Atmospherical Electricity* 50, 1945, pp. 139ff.; Schück, *Mitteilungen zur Geschichte der Medizin und der Naturwissenschaften* 13, 1914, pp. 335f., with the two short Latin texts). On Alexander Neckam see Düchting, article "Alexander Neckam" in *LexMA,* who ignores the mentioning of the magnetic needle in Neckam's treatises.

For an overview of the European sources on the magnetic compass see, for example, Mitchell, *Terrestrial Magnetism and Atmospherical Electricity* 37, 1932, pp. 123ff.; Schnall, article "Kompaß" in LexMA; Klaproth, *Lettre,* 1834, pp. 40f.

[5] On Petrus Peregrinus see Grant, article "Peter Peregrinus" in *DSB,* with a detailed list of manuscripts, editions and translations. On the *Epistola de magnete* see further Balmer, *Geschichte des Erdmagnetismus,* 1956, pp. 243–77, and p. 627. On the use of the magnetic compass at sea and on land see Schnall, article "Kompaß" in *LexMA;* Grant, article "Peter Peregrinus" in *DSB,* who assumes the use of the floating compass also for seafaring and of the dry compass for astronomical purposes; and Taylor, *Imago Mundi* 8, 1951, pp. 1f., who also distinguishes between its use in navigation and astronomy.

stone is enclosed in a small waterproof wooden box and put in a bowl filled with water, the rim of which is divided into 360 degrees. In addition, this box carries a sort of alidade in the form of a diametrical rule, for taking bearings.[6] For the latter, two needles of copper and iron fixed crosswise on one another are put into an axle with two holes perpendicular to the axis and perpendicular to each other (probably one slightly higher than the other). This device is squeezed into a small round box between the bottom and the transparent lid in such a way that it can rotate freely. The lid is divided into 360 degrees, and in addition a kind of alidade is attached to it. The iron needle is magnetized by bringing it close to a magnetic stone. In Europe and in China, a third use of the magnetic compass was the alignment of sacred architecture.[7] Further information is provided by the earliest European instruments fitted with a magnetic compass, but they date only from the second half of the fifteenth century.[8]

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[6] See, for example, the edition of Peregrinus's text in *Rara Magnetica,* 1898, pp. 36ff.; the German translation in Balmer, *Geschichte des Erdmagnetismus,* 1956, pp. 271ff., and the English translation in Harrandon, *Terrestrial Magnetism and Atmospherical Electricity* 48, 1943, pp. 3ff.; see further Schleif, *Seewart* 14:6, 1953, p. 25.

[7] On China see Klaproth, *Lettre,* 1834, p. 93, who cited *San thsaï thou hoei:* "Dans les années *Yan yeou* (de 1314 à 1320) on voulut orienter le monastère de *Yao mou ngan*, et on s'en [d'une figure sculptée en jade, et dont la main montrait toujours le sud] servit pour en déterminer l'emplacement" (my additions in square brackets). Also other buildings in Peking have probably been aligned in the meridian with a magnetic compass because they deviate from the meridian by 2 degrees according to the magnetic declination (see Klaproth, *Lettre,* 1834, p. 70). On Europe see Nippoldt, *Archiv für Geschichte der Naturwissenschaften und der Technik* 7, 1916, p. 110, who cited a treatise written in 1516 probably by Lorenz Lacher, one of the masters of the "Straßburger Bauhütte": "Item so du wildt ein Khor an das Hochwerkh anleg wo er stehn sol, der abmerckung, der sonen aufgang, so nimb ein Khumbast, setz den auf ein winkelmaß, und laß den magnad auf die mitdaglinie stehn, usw."

[8] On the earliest European compass-sundials see Zinner, *Instrumente,* 1956, p. 93; Zinner, *Regiomontanus,* 1938, fig. 62–65; Hellmann, *Meteorologische Zeitschrift* 23, 1906, pp. 145ff.; Hellmann, *Meteorologische Zeitschrift* 25, 1908, p. 369, mentioning one from 1451, another from 1463, both with a mark of the magnetic variation. King, *Ciphers,* section 6.3 (forthcoming) dates a medieval French compendium with a magnetic compass "to the fourteenth century, early or late, depending on the date of the astrolabe with ciphers" and continues: "Note the similarity of the inscriptions to those on the two Northern French astrolabes." On this instrument see further

Of concern for us here is a part of the area between China and Europe, namely, the world of Islam. Eilhard Wiedemann, whose essays on the history of Islamic science and technology are a gold-mine of information, greatly contributed to our understanding of the history and use of the magnetic compass in Islamic civilization. The earliest secure evidence attesting knowledge of the magnetic compass[9] is found in the Persian anthology *Jāmi*ᶜ *al-ḥikāyāt* by Sadīd al-Dīn Muḥammad ibn Muḥammad Bukhārī, known as ᶜAwfī, where an event during a voyage in the Red Sea or the Persian Gulf in the year 630H (1232–33) is related:[10] a fish made of iron is rubbed with a magnetic stone and then put in a bowl filled with water; it rotates until it stops pointing to the south.[11] The first full description of the

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Maddison, *Medieval Scientific Instruments,* 1969, pp. 14ff., dating it ca. 1500. A German astrolabe fitted with a magnetic compass in the throne probably from the second half of the fifteenth century is mentioned in King and Turner, *Nuncius* 9:1, 1994, pp. 190, 193, and fig. 18.

[9] In his "History of Africa and Spain" (*al-Bayān al-mughrib fī [ᵓkhtiṣār] akhbār mulūk al-Andalus wa-ᵓl-Maghrib*), written in 712H (1312–13), Ibn ᶜIdhārī (on whom see Bosch-Vilá, article "Ibn ᶜIdhārī" in *EI²*) reports of a battle in the year 239H (854). Dozy (see Dozy, *Supplément,* 1927, 2, pp. 337f.) found the word *qaramīṭ* in this context, which he translated as "magnetic needle." Even if we take into consideration that Καλαμίτα, as also in some European idioms (Italian, Greek and others) "calamita," means "magnetic needle" (see Klaproth, *Lettre,* 1834, p. 13; Heß, "Καλαμίτης," p. 189), this interpretation seems to be very doubtful (see Wiedemann, *VdDPG* 9, 1907, p. 765). It becomes apparent in the discussion on this reference that *qaramīṭ* cannot be interpreted as a first hint at the magnetic compass in Islamic sources (see Plessner, article "Baylak al-Qibjāqī" in *DSB,* p. 533b; von Lippmann, *QSGNM* 3:1, 1932, p. 16); von Lippmann, *QSGNM* 3:1, 1932, p. 20, mentions a further early reference to the compass from the twelfth century by ᶜUmar al-Khayyām (on whom see Youschkevitch and Rosenfeld, article "al-Khayyāmī" in *DSB;* Minorsky, article "ᶜOmar Khaiyām" in *EI¹*), which seems questionable to von Lippmann himself.

[10] On this author see Nizamuddin, article "ᶜAwfī" in *EI²;* Storey, *Persian Literature* 1:2, 1953, pp. 781ff. On the passage see Wiedemann, *VdDPG* 9, 1907, p. 765. The confusing dates—dedicated in 625H (1228), or again, dedicated to the *wazīr* of Iltutmish, Sultan of Delhi, Qiwām al-Dīn al-Junaydī not earlier than 628H (1230–31), but on an event in the year 630H (1232–33)—originate from the fact that the one is taken from Nizamuddin, article "ᶜAwfī" in *EI²,* p. 764a, and from Storey, *Persian Literature* 1:2, 1953, pp. 782f., while the other is from Wiedemann, *VdDPG* 9, 1907, p. 765.

[11] See Wiedemann, article "Maghnāṭīs, 2. The Compass," in *EI¹* and *EI²,* p. 1169a;

use of the magnetic compass for nautical purposes in the Islamic world is presented by Baylak al-Qibjāqī in his *Kitāb Kanz al-tujjār fī maᶜrifat al-aḥjār* written in 681H (1282).[12] There he describes the use of a floating compass during a sea voyage from Tripoli in Syria to Alexandria in the year 640H (1242–43).[13] An iron needle is joined crosswise with a rush and put in a bowl filled with water. Then a magnetic stone is brought close to this device, and the hand holding the magnetic stone describes a circle clockwise above it. The cross of the needle and the rush follows this move. When the magnetic stone is suddenly removed, the needle is supposed to be aligned with the meridian. In addition al-Qibjāqī reports that on the Indian Ocean floating compasses with a hollow floating fish made of sheet-iron were used.[14]

Further references to the magnetic compass in the Islamic world during the Middle Ages and the early Renaissance can be found in Taqī al-Dīn al-Maqrīzī's *al-Mawāᶜiẓ wa-ᵓl-iᶜtibār fī dhikr al-khiṭaṭ wa-ᵓl-athār*, a topography of Fusṭāṭ and Cairo and history of Alexandria and Egypt in general

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Wiedemann, *VdDPG* 9, 1907, pp. 765f.; von Lippmann, *QSGNM* 3:1, 1932, p. 20.

[12] Also *Kitāb Kanz al-tujjār fī maᶜrifat al-aḥjār*, see Plessner, article "Baylak al-Qibjāqī" in *DSB;* edition in Klaproth, *Lettre,* 1834, p. 59; with translation in Clément-Mullet, *Journal Asiatique* (série 6) 11, 1868, p. 174; translation in de Saussure, *L'origine,* 1928, pp. 80f. (reprint Ferrand); Wiedemann, "Beiträge II," 1904, pp. 330f.; Wiedemann, *VdDPG* 19–20, 1919, p. 665. On the contents see Ullmann, *Natur- und Geheimwissenschaften,* 1972, p. 128. On its integration into history see von Lippmann, *QSGNM* 3:1, 1932, pp. 17ff. On a further reference to the Arabic sources from the mid-thirteenth century see Mitchell, *Terrestrial Magnetism and Atmospherical Electricity* 37, 1932, p. 119 and note 180, citing the *Leyes de las partidas (Las siete partidas del Sabio Rey don Alfonso el X*, Madrid 1829, 1, p. 473), a compilation of the legal knowledge of Alfonso's time.

[13] Soucek, article "Milāḥa, 2. In the Later Medieval and Early Modern Periods," in *EI²,* p. 46a, ignores this passage when he writes: "The mariner's compass is first attested for 1187 [probably Alexander Neckam for the region of the Channel]. . . . The term, of Latin derivation, only marginally appeared in Arabic. . . . This term does not appear to have been current in pre-modern Arabic, a symptom of how little use the instrument received on the part of seafaring Arabs in the Mediterranean" (my addition in brackets). Mitchell, *Terrestrial Magnetism and Atmospherical Electricity* 37, 1932, p. 119, takes into consideration that ". . . it is carefully noted that he [al-Qibjāqī] said nothing as to the nationality of the vessel in which he sailed" (my addition in brackets).

[14] On the different nautical traditions in the Mediterranean and the Indian Ocean see Soucek, article "Milāḥa, 2. In the Later Medieval and Early Modern Periods," in *EI²,* p. 48b.

written about 800H (1400);[15] in Ibn Abī ʾl-Khayr al-Ḥusnī's *al-Nujūm al-shāriqāt*, a technical "cookery-book" on the production of colors and inks, the process of soldering, the handling of iron, etc., probably written in the second half of the sixteenth century;[16] and in treatises on navigation by Ibn Mājid from the second half of the fifteenth century[17] and by Sulaymān al-Mahrī from the first half of the sixteenth century.[18] Particularly important in this context is the treatise *Zahr al-basātīn fī ʿilm al-mashātīn* written by the Egyptian Muḥammad ibn Abī Bakr al-Zarkhūrī about 802H (1399–1400),[19] where two different kinds of magnetic compass are described. One instrument is a "fish" made of willow wood or pumpkin, into which a magnetic needle is inserted and which afterwards is sealed with tar or wax to prevent the penetration of water; this device swims on water. Instead of the fish a disk with the image of a *miḥrāb* or prayer-niche can be fixed on the magnetic needle.[20] The other instrument is a dry compass. The upper side of a disc of paper is decorated with the figure of a *miḥrāb*; two magnetized needles are fixed on the bottom and in the middle a thing like a funnel. This funnel rotates on an axis which is pivoted in the middle of a box sealed with a plate of glass to prevent the disc of paper from dropping.[21]

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[15] On the author see Rosenthal, article "al-Maqrīzī" in *EI*[2]. In this treatise a floating compass similar to al-Qibjāqī's is described. According to Wiedemann, *ZP* 24, 1924, p. 166, there are two editions: Būlāq, 1270H (on the magnetic compass 1, p. 210) and Cairo, 1324H (on the magnetic compass 1, p. 337).

[16] On the author see Suter, "Mathematiker und Astronomen," 1900, p. 200, no. 511; Wiedemann, *ZP* 13, 1923, pp. 113f.; Brockelmann, *GAL,* 1943, S II, p. 485; King, *Survey,* 1986, p. 89, no. C124.

This treatise is translated in Siggel, *QSGNM* 8 (1941–42): pp. 435–57.

[17] On Shihāb al-Dīn Aḥmad ibn Mājid, the most famous Arab navigator in the Middle Ages, see Maqbul Ahmad, article "Ibn Mādjid" in *EI*[2]*;* Tibbetts, *Arab Navigation,* 1971, pp. 7ff. On the use of a magnetic compass for determining the qibla in one of his poems, see Ferrand, *Instructions nautiques,* 3, 1928, pp. 209f. On the magnetic compass in his *Kitāb al-fawāʾid fī uṣūl [ʿilm] al-baḥr wa-ʾl-qawāʾid,* see Tibbetts, *Arab Navigation,* 1971, pp. 291ff.

[18] On Sulaymān ibn Aḥmad al-Mahrī see Tibbetts, article "Sulaymān al-Mahrī" in *EI*[2]. On the magnetic compass in his *Kitāb sharḥ Tuḥfat al-fuḥūl fī tamhīd al-uṣūl* see Ferrand, *Instructions nautiques,* 3, p. 245; see further Tibbetts, *Arab Navigation,* 1981, pp. 293f.

[19] On the author see Brockelmann, *GAL,* 1943, 2, p. 174; partial translation in Wiedemann, *VdDPG* 9, 1907, pp. 766ff.

[20] See Wiedemann, *VdDPG* 9, 1907, pp. 767ff.

[21] See Wiedemann, *VdDPG* 11, 1909, pp. 264f. Unfortunately he gives—as usual in his writings—only a translation; a comparison with the Arabic terms of Ibn

Several kinds of Islamic instruments featuring a magnetic compass were unknown to Eilhard Wiedemann and should be mentioned here. The *ṣandūq al-yawā*qīt made by ᶜAlāᵓ al-Dīn Ibn al-Shāṭir, an astronomical "compendium" or multifunctional device seems to be the earliest Islamic instrument fitted with a dry magnetic compass. Only one device made by Ibn al-Shāṭir himself in 767H (1366) survives.[22] Further instruments fitted with a magnetic compass to orient them in the cardinal directions are the *dāᵓirāt al-muᶜaddal*, "equatorial" (semi-)circles. Devised in Egypt in the fifteenth century, they were used in the Ottoman world.[23] Of greater historical interest is a ceramic bowl for a floating compass made in Damascus, datable about 1520. The inscriptions on this piece include qibla values for 40 cities, and prove that it belongs to a Persian tradition that predates this particular instrument by at least two centuries.[24] Further Islamic instruments fitted with a magnetic compass are known, but all of them postdate 1600.[25] Summing up, it may be said that the previously known Islamic sources on the magnetic compass first mention the floating compass, followed by the dry compass. Originally magnetic compasses are described primarily as nautical instruments, later as qibla indicators or components of astronomical instruments.[26]

Simᶜūn's treatise discussed below would be useful and worthwhile.

[22] On the author see King, article "Ibn al-Shāṭir" in *DSB.* For a discussion of the instrument, and two medieval texts on the use of the compendium, likewise incomplete, see Janin and King, *Journal for the History of Arabic Science* 1:2, 1977. On the magnetic compass see especially ibid. pp. 192, 195f., 204, 209, 215ff.

[23] See, for example, Dizer, *Journal for the History of Arabic Science* 1, 1977, pp. 257–62, and the literature there cited.

[24] See King, *Imago Mundi* 49, 1997, pp. 62–82, a summary of King, *World-Maps for Finding the Direction and Distance to Mecca: Innovation and Tradition in Islamic Science,* 1999 (in press at the time of this writing).

[25] There are, for example, a Persian prayer compass, made by one Muḥammad Ṭāhir in Isfahan in the seventeenth century and inscribed with qibla values of localities as well as with instructions for its use (on the instrument see Körber, *Sonnenuhren und Kompasse,* 1965, pp. 98f.; on the maker see Mayer, *Islamic Astrolabists,* 1956, p. 78), and two cartographic plates, made in Isfahan about 1700 and fitted with compass box up in the lower middle (on the one with a now empty compass box see King, "Weltkarten," 1992, 1, p. 170 with fig. 4 and 2, pp. 686ff.; King, "Astronomical Instruments," 1994, p. 173 and fig. XVIa; on both see King, *Imago Mundi* 49, 1997, pp. 62–82; King, *World-Maps* [in press at the time of this writing]).

[26] On the use of the magnetic compass at sea see Tibbetts, article "Milāḥa, 3. In the Indian Ocean," in *EI²,* p. 51b, mentioning a further nautical instrument, the

Against this background we now introduce two new textual sources on the magnetic compass; for each the Arabic text with a translation will be presented, followed by a commentary.

2. Al-Ashraf's treatise

Al-Ashraf ᶜUmar ibn Yūsuf was the third Rasulid sultan of the Yemen, reigning from 694H (1294–95) to his death in 696H (1296–97). He followed his father, the sultan al-Muẓaffar Yūsuf on the throne.[27] He was of minor importance for the political history of his realm, but is of considerable importance to the history of science. According to the statement of his teachers,[28] he wrote several important and sophisticated scientific works,[29] including one on the construction of astrolabes and sundials, and, in addition, he constructed several astrolabes, one of which is preserved in the Metropolitan Museum of Art in New York.[30] At the end of his treatise, we find two short statements, one on the water-clock and one on the magnetic compass and the determination of the qibla.[31]

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khashaba. On the rare appearance of the magnetic compass in navigational texts see Tibbetts, *Arab navigation,* 1971, p. 290. On other nautical instruments in the Islamic world see also Prinsep, *Journal of the Asiatic Society of Bengal* 5, 1836; Jomard, *Bulletin de la Société de Géographie* 2:10, 1838.

On the sacred direction in Islam, the qibla, see King, article "Ḳibla, 2. Astronomical Aspects," in *EI²;* King, *Interdisciplinary Science Reviews* 10:4, 1985, pp. 315ff.

27 On Sultan al-Ashraf see Varisco, *Almanac,* 1994, pp. 12ff., and the literature cited there; see further Suter, "Mathematiker und Astronomen," 1900, pp. 160f., no. 394; King, *MAY,* 1983, pp. 27f.; King, *ZGAIW* 2, 1985, p. 100. On the Rasulids see Smith, article "Rasūlids" in *EI²,* and the literature cited there.

28 See King, *ZGAIW* 2, 1985, p. 113.

29 A list is given in Varisco, *Almanac,* 1994, pp. 14ff.; see further King, *MAY,* 1983, pp. 27ff.

30 See Mayer, *Islamic Astrolabists,* 1956, pp. 83f. A detailed description is given in King, *ZGAIW* 2, 1985, pp. 99f.

31 On astrolabes in general see Hartner, "The Principle and Use of the Astrolabe," 1968; North, "The Astrolabe," 1974; Michel, *Traité de l'Astrolabe,* 1947; *Planispheric Astrolabe,* 1976. On sundials in Islamic civilization see King, article "Mizwala" in *EI²*. On water-clocks see Hill, *Arabic Water-Clocks,* 1981; King, *History of Science* 15, 1977. On the magnetic compass in the Islamic world in general see Wiedemann, article "Maghnāṭīs, 2. The Compass," in *EI¹* and *EI²;* King, article "Ṭāsa" in *EI²*.

Al-Ashraf's text was treated by S. Banerjee and A. I. Sabra in a paper entitled "A Thirteenth-Century Magnetic Compass Described by Sultan al-Ashraf of Yemen"

Three complete manuscripts of al-Ashraf's treatise on the magnetic compass are known, as well as a manuscript containing merely a part of the chapter on the magnetic compass.

The most significant manuscript is preserved in the Egyptian National Library (Dār al-Kutub al-Miṣrīya) in Cairo with the signature TR (Taymūr *riyāḍa*) 105 —henceforth labeled C.[32] It was copied in the Yemen in 692H (1293).[33] The text bears the title *Muᶜīn al-ṭullāb fī ᵓl-ᶜamal bi-ᵓl-asṭurlāb*, which is probably not original. Altogether it has 149 folios;[34] the section on the magnetic compass *Dhikr risālat al-ṭāsa*, which interests us here, begins on fol. 143r and ends on fol. 146r.

Another manuscript preserved in the library of the Majlis al-Umma al-Īrānī (No. 150) in Tehran,[35] consists of three parts, each being separately paginated, and written in two different hands.[36] It contains the chapter on the magnetic compass twice, henceforth abbreviated as T_1 and T_2. The first part of the Tehran manuscript is datable about 900H (1500).[37] The *Dhikr risālat al-ṭāsa* (T_2) is contained in pages 3 to 8. The third part of the Tehran manuscript is dated 7 Dhū ᵓl-Qaᶜda 888H (7 December 1483), and bears the title *Minhaj al-ṭullāb fī ᵓl-ᶜamal bi-ᵓl-asṭurlāb,*[38] which is probably not original.[39] The *Dhikr risālat al-ṭāsa* (T_1) is contained in pages 159 to 163.[40]

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presented at the Second International Symposium on the History of Arabic Science, Aleppo, 1979. The proceedings of that conference were never published and the paper has not been published elsewhere. The authors used photos provided by Prof. King.

[32] See King, *Catalogue,* 1981–86, 1, p. 581, and 2, pp. 362ff.; King, *Survey,* 1986, p. 132, no. E8; with more details—with reference to the Tehran manuscript—King, *MAY,* 1983, pp. 28f.; King, *ZGAIW* 2, 1985, pp. 101f.

[33] On the date see King, *Catalogue,* 1981, 1, p. 581; King, *ZGAIW* 2, 1985, p. 101, note 8. On the provenance see King, *ZGAIW* 2, 1985, p. 107. On the copyist see King, *ZGAIW* 2, 1985, p. 101.

[34] See King, *Survey,* 1986, p. 132.

[35] See King, *ZGAIW* 4, 1987–88, pp. 268f.; King, *ZGAIW* 2, 1985, p. 108; Al-ᶜAzzāwī, *Tārīkh ᶜilm al-falak,* 1959, p. 234, mentions two manuscripts in Tehran: one in the library of the Majlis al-Umma al-Īrānī and another in a private library.

[36] Part 1 (hand A): pp. 1–8, part 2 (hand A): pp. 1–126, part 3 (hand B): pp. 1–163 (see King, *ZGAIW* 4, 1987–88, p. 269).

[37] See King, *ZGAIW* 4, 1987–88, p. 268.

[38] Also *manhaj*, see King, *ZGAIW* 2, 1985, p. 108. On the contents of the manuscript see King, *ZGAIW* 4, 1987–8, p. 269.

[39] See King, *MAY,* 1983, p. 28; King, *ZGAIW* 2, 1985, p. 108.

[40] Consequently, between p. 161 and p. 162 one page of text is missing, the

In a manuscript in Berlin (Staatsbibliothek Stiftung Preußischer Kulturbesitz, Orientabteilung, Ahlwardt Nr. 5811, 2, Sprenger 1870, 1), an anonymous addition to the treatise on the magnetic compass is found, henceforth abbreviated as B. It dates from the year 1114H (1702–3). The complete manuscript of 19 folios has the title *Risālat asṭurlāb*, but this has been added later; the text contains a treatise on the astrolabe.[41] The text on fol. 12a deals with the compass bowl under the heading *ᶜAmal al-ṭāsa li-maᶜrifat ikhrāj al-qibla wa-ᵓl-jihāt*. A German translation was published by Wiedemann,[42] and it was his translation that enabled me to identify this fragment as being al-Ashraf's work. Neither Ahlwardt nor Wiedemann were aware of the origin of the treatise, nor King of the manuscript.

The basis of the following Arabic text and the translation is C. It is written in a clear and clean *naskhī* hand. Moreover it is the earliest and most complete copy and is without noticeable mistakes in content. Hamzas and diacritical points missing in the original have been silently added in my edition. Occasional differences between T_1, T_2 and B are noted in the critical apparatus. The punctuation of the translation follows the English usage. Additions facilitating understanding, but without equivalents in the texts, are in parentheses. Uncommon Arabic terms are likewise given in parentheses. These are also included in the glossary.

2.1. Arabic text

ذكر رسالة الطاسة في [١] معرفة القبلة [١] [٢] .

بسم الله الرحمن الرحيم ❖ [٣] . الحمد لله [٤] الرحيم الرحمن [٤] ❖ [٥] ، الواهب [٦] المنان ❖ [٧] ، وصلواته [٨] على نبيه الذي أنزل عليه القرآن ❖ [٩] ، وعلى أهله [١٠] أفضل الصلاة [١١] والغفران [١٢] . وبعد:

فهذه رسالة في أوضح البيان ❖ [١٣] في معرفة العمل بالإبرة وانحراف القبلة لكل مكان ❖ . وبالله أستعين (144r) وأتوكل ❖ [١٤] وعليه أعتمد فيما

pagination, however, is continuous. The question is whether the pagination is on the microfilm or whether it has been added later (corresponding references in King, *ZGAIW* 4, 1987–8, p. 269).

41 See Ahlwardt, *Verzeichnis,* 1893, pp. 240f.

42 See Wiedemann, *VdDPG* 19–20, 1919, p. 666. It is also mentioned in Wiede-

غرب وأشكل . وأول [١٥] ما تبتدي به من العمل [١٥] أنك تعمل طاسة من فضة أو نحاس متوسطة القدر عريضة الشفة صحيحة بحيث تمشي المسطرة على شفتها مصطحبة على الاستواء كحجرة الأصطرلاب . ثم تملأ الطاسة قارا أو شمعا يذاب [١٦] ويصب فيها حتى تمتلي ويصير مع مسحة الشفة سواء . ثم تأخذ صفيحة من نحاس وتوضع في وسط الطاسة تنزل [١٧] في القار أو في الشمع ويكون المركز فيها بعد تخط في وسط الطاسة [١٧] إلى شفتها الأخرى بالمسطرة خطا مستطيلا ، وهو خط الشمال والجنوب ، وخطا آخر بالعرض مستطيلا من شفة الطاسة إلى الشفة المقابلة لأول الخط ، ويسمى خط المشرق والمغرب . فحينئذ يتقاطع الخطان في وسط الصفيحة سواء فيكون مركز البيكاز في وسط التقاطع ، وتقسم عرض الشفة أربعة أقسام ، فتدير على القسم الذي يلي شفة باطن الطاسة دائرة ، ثم تعفي قسمين من بعدها وتديره على القسم الرابع مما يلي شفة ظاهر الطاسة دائرة ، ثم تقسم الدائرة ، وتسمى دائرة الدرج ، التي تلي باطن الطاسة ثلثمائة وستين قسما أجزاء متساوية ، ويسمى كل قسم منها درجة . وتقسم الدائرتين المعقبتين [١٨] اللتين [١٩] بعد هذه الدائرة ، وهي دائرة أعداد الأخماس ، اثنين وسبعين قسما ، كل قسم منها خمس درج ، وتكتب فيه الأعداد المفردة ، ويأتي ذكرها في مثال دائرة شفة الطاسة إن شاء الله تعالى . ثم تقسم دائرة الربع التي خلف هذه الدائرة مما تلي شفة ظاهر الطاسة أربعة أقسام متساوية ، وتكتب على كل قسم منها (144v) شمال [٢٠] جنوب [٢١] مشرق [٢٢] مغرب [٢٣] وقد كملت .

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mann, article “Maghnāṭīs, 2. The Compass,” in *EI*[1] and *EI*[2].

فإذا [٢٤] أردت معرفة خط نصف النهار بأقرب [٢٥] تقريب وبأهون عمل [٢٥] فاملأ الطاسة ماء وضعها [٢٦] في مكان مستو من الأرض من غير انخفاض ولا ارتفاع بل يكون مصطحبا مصونا عن الهواء لئلا [٢٧] تضطرب الإبرة [٢٦] . ثم تأخذ [٢٨] إبرة من البولاذ [٢٩] وتحك [٣٠] رأسها بحجر المغناطيس حكا جيدا ، وأجوده الأسود [٣١] والبصاص فإنه من الخواص . ثم [٣٢] تأخذ [٣٢] سمارة ، وهي قشة من الحشيش أو من شجر الحص أو من [٣٣] التبن [٣٤] ، وهو أجودها ، ويكون طولها بقدر طول الإبرة ، ثم تنزل فيـ[ـه] الإبرة في نصف طول السمارة وتخرجها حتى تبلغ السمارة إلى نصف الإبرة وتصير هي والإبرة كالصليب ، هكذا [٣٥] –|– [٣٦] . وتوضع [٣٧] حينئذ [٣٨] الإبرة في الماء ، فعند ذلك تدور [٣٩] الإبرة إلى أن تقف [٤٠] على خط وسط [٤١] النهار تقريبا ، فتارة يكون رأسها الحاد الذي حككته على الحجر مقابلا لخط الشمال وتارة يكون مقابلا لخط الجنوب وموضع مدخل الخيط الذي لم تحك مقابلا للشمال ، وليس على ذلك معول كيف [كذا] قابل رأسها خط الشمال أو جهة الجنوب ، إذ كان لا يتغير أحد رأسيها [٤٢] عن طلبة [٤٣] الشمال أو الجنوب ، وبأي الجهة [٤٤] كان تعرف بوقوفها خط نصف النهار بالتقريب على طول الإبرة . فإذا عرفت خط نصف النهار الذي هو من [٤٥] نقطة [٤٦] الشمال إلى [٤٦] نقطة الجنوب ، واعرف حينئذ [٤٧] [أن] رأسي السمارة أحدهما إلى المشرق والآخر إلى المغرب [٤٨] . فإن مالت الإبرة عن وسط الطاسة إلى أحد جوانبها فحركها بشيء لطيف [٤٩] بيدك أو قرب إليها حجر المغناطيس حتى يحاذي رأسها نقطة الشمال وتصير في وسط الطاسة .

والعمدة [٥٠] في معرفة سمت القبلة إقعاد الإبرة (145r) فوق حقيقة مركز

الطاسة بحيث تكون نقطة تقاطع الإبرة مع السمارة مسامتا لمركز الطاسة ولا تميل عن مركزها ولو بقدر ذرة فيحصل الخلل عن جهة القبلة بقدر ذلك الميل ، بل تكون نقطة تقاطع الإبرة والسمارة ، وهي القشة ، فوق الماء مع استواء مركز الطاسة من غير زيغ ، فحينئذ يكون خط نصف النهار قبالة رأس الإبرة . ويتوخى أن لو أقيم خط مستقيم يمر من رأس الإبرة إلى أن يمر بقسم من الأقسام المقسومة بشفة الطاسة فذلك القسم المقابل لرأس الإبرة هو انحراف خط نصف النهار بالتقريب ، وهو نقطة الشمال . فتنقص من النقطة الشمالي [كذا] إلى [٥١] جهة المشرق بقدر ما أوجبه الانحراف للقبلة من الجدول العشريني . وإن استقامت الإبرة في وسط الطاسة وكان رأسها إلى جهة من الجهات النكب [٥٢] ولم تكن مقابلة لنقطة الشمال فأدر الطاسة [٥٣] حتى يحاذي رأس الإبرة لنقطة الشمال التي في وسط الطاسة ، فإذا حاذت فحينئذ تصح الجهات الأربع بأقرب تقريب كما ذكرناه . وهذه [٥٤] الآلة ليست بمفتقرة [٥٤] إلى رؤية شمس أو كوكب بل غنية بذاتها ، وتظهر [٥٥] خط نصف النهار والجهات كلها في صحو أو غيم بليل أو نهار . فإذا عرف بها خط الشمال وأردت [أن] تعرف حينئذ انحراف القبلة لكل بلد على قدر موضع الانحراف من الجدول العشريني لإخراج انحراف القبل [٥٦] ، فإذا [٥٧] أردت معرفة انحراف القبلة [٥٧] ، فعد من شفة الطاسة من قبالة رأس الإبرة الذي هو نقطة الشمال إلى جهة المشرق كز ، وذلك سبعة [كذا] وعشرون درجة ، فالدرجة [٤٩] السابعة العشرون هي انحراف قبلة وسط اليمن بعدن وتعز وزبيد [٥٨] ، وخط حينئذ خطا في الأرض موازيا لنقطة الشمال وخطا من المركز إلى الدرجة السابعة والعشرين التي هي انحراف قبلة وسط اليمن

فصل إليها ، لأن متى عرف خط الشمـــال تريد [أن] تعرف انحراف القبلة (145v) لكل بلد من الأقاليم على قدر موضع الانحراف وما تخصه من الدرج المحيطة [٥٩] بدائر شفة الطاسة جميعها . وهذه صورة الدائرة التي تعمل على [٦٠] شفة [٦١] الطاسة وأعدادها المفردة من غير تركيب وصورة الإبرة في وسطها ❖ [٦١] :

The diagram with the inscription follows. There are three circles; the outer circle is divided into four parts marked: *al-janūb* (above), *al-maghrib* (right), *al-shimāl*[٦٢] (below), *al-mashriq* (left), *qiblat Taᶜizz*[٦٣] (from north to west near 20°), *qiblat ᶜAdan*[٦٤] (from north to east near 20°). The middle circle is divided into 72 equal parts marked for every five degrees. The innermost circle is divided into 360 parts marked for every degree with a short stroke. In the center are two lines from south to north and from east to west marked: *wuqūf al-samāra fī ᵓl-ṭāsa*[٦٥] *muqābila khaṭṭ al-mashriq wa-ᵓl-maghrib* (by the east-west line), *wuqūf al-ibra fī ᵓl-ṭāsa muqābila khaṭṭ niṣf al-nahār* (by the north-south line).

وترتيب [٦٦] هذه الكتابة [٦٦] أنك تكتب في أول قسم عند خط الشمال مما يلي اليمين ه [٦٧] ، وذلك خمسة ، وفي القسم الثاني ي [٦٨] ، وذلك عشرة ، ثم باقي الأقسام على هذه الصورة ، (146r) قسم أحاد وقسم أعشار ، حتى يكون آخر القسم الذي عند خط [٦٩] المشرق ص . ثم تكتب في القسم الذي يليـــه من ناحية الجنوب ص أخرى ، حتى يكـــون خط المشرق بين صادين . ثم بعد الصاد ه ، وتستمر إلى آخر القسم الذي عند خط الجنوب ، وهو ه . ثم تكتب في القسم الذي يليه ه وتستمر إلى آخر القسم الذي يليه خط المغرب ، وهو ص . وتكتب في القسم الذي يليه ص أخرى ، حتى يكون خط المغرب بين صادين ، وتستمر إلى آخر خط القسم الذي عند خط وسط السمـــاء ، وهو ه [٧٠] ، وقد كمل الجميع [٧١] .

وإلى [٧٢] هاهنا [٧٢] انتهي الكلام في عمل رسالتي الأصطرلاب [٧٣] والترجهار [٧٤] ❖ ، والرخامة ❖ ، ورسالة الطاسة في معرفة القبلة بحسب الاجتهاد والبحث مع الفضلاء من أرباب هذه الصناعة ومفاوضتهم ومشاهدة ما صوروه بعد المفاوضة حتى شاركناهم فيما قد [٧٥] حصل عندنا من الفائدة . فوضعنا حينئذ ما قد وضعناه من الأعمال في كتابنا هذا ❖ [٧٦] . فمن وقف عليه فليبسط عذرنا [٧٧] لديه [٧٧] ❖ ، فنحن مشاركون لا مدعون ❖ [٧٨] ، ومجتهدون لا مناظرون ❖ [٧٩] . ونسأل الله تعالى الإعانة والزيادة ❖ [٨٠] ، والإلهام إلى بلوغ الإرادة [٨١] ❖ ، بمنه وطوله ❖ ، وقوته [٨٢] وحوله ❖ ، وهو حسبي وكفى ❖ . تمت الرسائل [٨٣] .

والحمد لله وحده ، وصلواته على رسوله [٨٤] سيدنا محمد النبي وآله [٨٥] وسلامه [٨٦] .

Notes on al-Ashraf's Text

١–١	illegible in T_2
٢	❖ follows in T1
٣	missing from T_2
٤	الرحمن الرحيم in T1
٥	missing from T_2
٦	المنعم follows in T_1, T_2
٧	missing from T_1, T_2
٨	صلوته in T_1, T_2
٩	missing from T_2
١٠	آله in T_1, T_2
١١	الصلوة in T_2

١٢ القرآن in T_1, T_2

١٣ missing from T_1, T_2

١٤ missing from T_2

١٥–١٥ وأول – العمل illegible in T_2

١٦ مذاب in T_1, T_2

١٧–١٧ تنزل – وسط الطاسة missing in T_1, T_2

١٨ repeated T_1, T_2

١٩ اللذين in C, الذي in T_1, T_2

٢٠ ❖ follows in T_1, T_2

٢١ ❖ follows in T_1, T_2

٢٢ ❖ follows in T_1, T_2

٢٣ ❖ follows in T_1, T_2

٢٤ B begins, entitled عمل الطاسة لمعرفة إخراج القبلة والجهات

٢٥–٢٥ باقرب – عمل missing in B

٢٦–٢٦ وضعها – الإبرة missing in B

٢٧ اليلا T_1, T_2 (not punctuated)

٢٨ marginal note in C; وخذ in B

٢٩ بولاد in T_1, T_2, B

٣٠ وحك in B

٣١ الأسد in B

٣٢ illegible in T_2

٣٣ missing from B

٣٤ التين in T_1, T_2

٣٥ missing from B

٣٦ illegible in T_2

٣٧ ثم تضع in B

٣٨ missing from B

٣٩ تدير in B

٤٠ تقيف (not punctuated) in T_2

٤١ نصف in B

٤٢ سيما follows in T_1

٤٣ طلب in B

٤٤ جهة in B

٤٥ في in B

٤٦–٤٦ إلى – نقطة missing in B

٤٧ نخ (not punctuated) in B

٤٨ B ends

٤٩–٤٩ فالدرجة – لطيف missing in the copy of T_1 at the author's disposal

٥٠ illegible in T_2

٥١ crossed out, then repeated in C

٥٢ الثلث in T_2

٥٣ وكان رأسها الى جهة من الجهات الثلث follows in T_2 (cf. previous sentence)

٥٤–٥٤ بمفتقرة – وهذه illegible in T_2

٥٥ تظهر in T_2

٥٦ قبلة in T_2

٥٧–٥٧ القبلة – فإذا illegible in T_2

٥٨ زبيل (not punctuated in) T_2

٥٩ المحيط in T_1, T_2

٦٠ below the line T_2

٦١ missing from T_2

٦٢ لعدن near it T_1, T_2

٦٣ mark not inscribed T_1, T_2

٦٤ تعز in T_1, T_2

٦٥ طاس in T_2

٦٦–٦٦ الكتابة – وترتيب illegible in T_2

٦٧ illegible in T_2

٦٨ illegible in T_2

٦٩ missing from T_1, T_2

٧٠ illegible in T_2

٧١ ❖ follows in T_1

٧٢–٧٢ illegible in T_2

٧٣ ❖ follows in T_1, T_2

٧٤ marginal note in C

٧٥ missing from T_1, T_2

٧٦ missing from T_2

٧٧ عدرنا لبرية in T_1; illegible in T_2

٧٨ missing from T_1, T_2

٧٩ missing from T_1, T_2

٨٠ missing from T_2

٨١ الازادة in T_1

٨٢ بوته (first letter not punctuated) in T_1

٨٣ colophon follows in T_2 (illegible in the copy of T_2 at my disposal)

٨٤ قويات وصححت بحسب الطاقة والإجتهاد over the line T_1

٨٥ وصحة follows in T_1

٨٦ تحريره في سبع شهر ذو القعدة سنة ٨٨٨ follows in T_1

2.2. Translation

On the Use of the Compass Bowl (ṭāsa)[43] *for the Determination of the Qibla*.[44] In the name of God, the Merciful and Compassionate, praise be to God, the Compassionate and Merciful,[45] the Giver and Benefactor. May His

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43 Al-Ashraf describes both the making of the compass bowl and its use using the term *ṭāsa* for a (drinking) bowl (of metal) (see Lane, *Lexicon,* 1863–1893, 5, p. 1890, sub *ṭ-w-s*), which is to translate—as the manuscript shows—as a *pars pro toto* with "magnetic compass."

44 The Arabic *Dhikr risālat al-ṭāsa fī maᶜrifat al-qibla*, at first sight rather awkward, is probably best rendered in this way. The use of the word *risāla* apparently corresponds to the use of the word *bāb* for "method" in scientific Arabic (see King, *ZGAIW* 3, 1986, p. 103).

45 The order of C here seems to be required by the *sajᶜ*. T_1 and T_2 have the normal order *the Merciful and Compassionate*.

blessings be upon His Prophet to whom He revealed the Koran, and His most excellent salvation and forgiveness upon his family.

This is a treatise presented in the clearest possible terms on the knowledge of the use of the needle (*ibra*)[46] and the direction (*inḥirāf*) of the qibla for all localities. I seek help from God [144r] and place my trust in him. I rely on Him in that which is obscure and difficult. You begin by making a bowl of silver or brass of medium size and with a broad rim, level (*ṣaḥīḥa*) so that (the tip of) the ruler moves on its rim evenly, like the rim (*ḥujra*)[47] of the astrolabe. Then you fill the bowl with tar or wax,[48] which is melted and poured into the bowl until it is full and (the liquid) is evenly level with the rim (*ma*ᶜ*a masḥat al-shafa sawā*ᵓ). Then you take a plate of brass and put it in the middle of the bowl, so that it sinks into the tar or the wax. The center will be on it. Then you draw with the ruler a straight line across the middle of the bowl to the other rim—which is the north-south line—and another perpendicular straight line from the rim of the bowl to the (point on the) rim opposite the beginning point of the line—which is called the east-west line. At this point the two lines will intersect each other exactly in the middle of the plate. The center of the compass will be at the point of intersection. You divide the breadth of the rim into four parts and describe a circle on the part

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46 *Bayt al-ibra* is one of the terms for the magnetic compass in medieval Arabic sources (see, for example, Wiedemann, article "Maghnāṭīs, 2. The Compass," in *EI*[1] and *EI*[2], p. 1169a).

47 See Wiedemann and Frank, *Zeitschrift für Instrumentenkunde* 41, 1921, p. 226; Kunitzsch, "Glossar," 1982, pp. 523f.: "Die Vokalisierung des arabischen Wortes ist unsicher. In der hier eigentlich anzunehmenden Bedeutung 'Rand' (Zaun, Einfriedung) wäre *al-ḥajra* (mit *a*) zu vokalisieren. . . . Sehr viel öfter haben die Hss. (und Drucke) dagegen die Vokalisierung mit *u*: *al-ḥujra . . . ; al-ḥujra* bedeutet jedoch eigentlich ein abgegrenztes Feld oder einen geschlossenen Raum (modern: 'Zimmer'), und würde demnach eher auf die von dem Außenrand umschlossene Innenfläche bzw. den Innenraum als auf diesen wulstigen Außenrand selbst zielen."; Hartner, "The Principle and Use of the Astrolabe," 1968, p. 293, vocalizes *ḥajra*: "The front [of the astrolabe] consists of a circular outer rim (Arabic: *ḥajra*, meaning 'side,' or *ṭawq*, meaning 'ring,' or *kiffa*, meaning 'curve'; Latin: *limbus* or *margo*)."

48 *Qār* was used to seal up vessels and wine tubes and also to rub camels having the mange (see Lane, *Lexicon,* 1863–1893, 7, p. 2557, sub *q-y-r* and 7, p. 2621, sub *k-f-r*; *shama*ᶜ describes also wax candles. Ullmann, *Natur- und Geheimwissenschaften,* 1972, p. 127, mentions that al-Qazwīnī in his cosmography attaches tar to a group of "viscous substances," and so does Ḥamd Allāh Mustawfī (see Ullmann, *Natur- und Geheimwissenschaften,* 1972, p. 131). Tar or pitch is mentioned in several stone books (see Ullmann, *Natur- und Geheimwissenschaften,* 1972, pp. 95ff.).

next to the inner rim of the bowl. Then you obliterate two parts of its distance. You describe a circle on the fourth part next to the outer rim of the bowl, and then you divide the circle—which is called the degree scale (lit. circle of degrees)—which is next to the inner rim of the bowl into three hundred and sixty equal parts, each of which is called a degree. You divide the next two circles which follow this circle— namely, the circle of the five (degree) arguments (*dāʾirat al-aʿdād al-akhmās*)—into seventy-two parts, each part of which consists of five degrees, and you write the individual numbers on it. This will be mentioned in the diagram (*mithāl*) of the circle on the rim of the bowl, God Almighty willing. Then you divide the (so-called) circle of the quadrant outside this circle and next to the outer rim of the bowl into four equal parts and write [144v] *north, south, east,* and *west,* respectively, on each of its parts, whereupon (the bowl) is finished.

If[49] you wish to determine the meridian (lit. line of midday, *khaṭṭ niṣf al-nahār*) as nearly and as easily as possible, then fill the bowl with water and place it in a level spot on the ground which slopes neither upwards nor downwards but which is even and well protected against the wind, lest the needle be disturbed. Then you take a steel needle and rub its head well with a magnetic stone. The best (species) is the black and bright[50] (variety), which has especially sympathetic qualities (*fa-innahu min al-khawāṣṣ*).[51] Then you take a (slender) rush-like stem,[52] be it a stalk of grass, or saffron,[53] or straw, the (last mentioned) being best. Its length should be the same as the length of the needle. You insert the needle into the rush-like stem at half length and push it through until the stem reaches the middle of the needle. (The rush-like stem) and the needle will then form a cross, thus: –|– . Now the needle is placed on the water, and it rotates until it stops approximately

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[49] The translation of B in Wiedemann, *VdDPG* 19–20, 1919, p. 666, begins at this point.

[50] Wiedemann, *VdDPG* 19–20, 1919, p. 666, translates: “Der beste ist der Löwe und der mit glänzendem Auge (*baṣāṣ*).”

[51] See Ullmann, article “Khāṣṣa” in *EI²;* Ullmann, *Natur- und Geheimwissenschaften,* 1972, pp. 393ff. Magnetite (Fe_3O_4) is a black, metallic bright, non-transparent, cubic mineral. Larger pieces are natural magnets. Wiedemann, “Beiträge II,” 1904, p. 328, mentions a passage in al-Tifāshī also describing the magnetic stone as a black stone.

[52] Wiedemann, *VdDPG* 19–20, 1919, p. 666, does not translate *samāra*, whereas in his “Beiträge II,” 1904, p. 330, he uses “Binse,” i.e. “rush”; Dozy, *Supplément,* 1927, 1, p. 682, sub *samār*, *simār* or *sumār* mentions several sorts of rush.

[53] Wiedemann, *VdDPG* 19–20, 1919, p. 666, reads *ḥaṣīr,* and freely translates “Binse,” i.e., “rush.”

on the meridian (*khaṭṭ wasaṭ al-nahār*). Sometimes the sharp head (of the needle), which you have rubbed on the stone, faces north, and sometimes it faces south, whereas the place for inserting the thread, which you did not rub, faces north. There is no way to predict which will occur. But whether its head faces north or south, for one of the needle's two heads will always be attracted to the north or to the south,[54] and whatever direction it points to, you will know from how it stops that the meridian, approximately, is parallel to the length of the needle. When you have ascertained the meridian, which is from the north point to the south point, you will know (that) one of the two heads of the rush-like stem points east and the other west.[55] If the needle moves away from the middle of the bowl to one of its sides, push it a little bit with your hand or bring the magnetic stone close to it, until its head is opposite the north point and it is back in the middle of the bowl.

The essential thing in determining the direction of the qibla is to place the needle [145r] exactly over the center of the bowl in such a way that the intersection of the needle with the rush-like stem is directly above the center of the bowl and does not deviate from it, not even a little. Otherwise there might result an error in the direction of the qibla equivalent to this deviation (*mayl*). The intersection of the needle and the rush-like stem—that is, the stalk—on the water should be precisely over the center of the bowl without any divergence (*zaygh*). Then the meridian will be facing the head of the needle. Let us imagine that a straight line is drawn from the head of the needle so that it passes through one of the divisions on the rim of the bowl. This division opposite the head of the needle will then represent approximately the deviation of the meridian, which is the north point. From the north point, you subtract towards the east (the amount) necessary for the deviation of the qibla in the 20×20 table (*al-jadwal al-ᶜishrīnī*). If the needle rests in the middle of the bowl and its head is pointing in one of the intermediate non-cardinal directions (*al-jihāt al-n-k-b*) and is not facing the north point, then

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[54] Wiedemann, *VdDPG* 19–20, 1919, p. 666, translates: “Es ist in Bezug hierauf nicht abzusehen, wie ihr (der Nadel) Ende der Linie des Nordens oder der Richtung nach Süden gegenüberliegt, wenn nicht eines ihrer Enden eine solche Veränderung erfahren hat, daß es nicht (auch) nach dem Norden oder nicht (auch) nach dem Süden hinstrebt.” And he comments: “Der Verfasser meint, daß, wenn beide Seiten beim Reiben so verändert wären, daß sie dem Norden bzw. dem Süden zustrebten, eine Einstellung in die Nord-Süd-Richtung nicht eintreten würde; es mußte also das nicht geriebene Ende eine solche Veränderung erfahren haben, daß dies nicht geschieht.” Cf. below in the commentary, pp. 104–5.

[55] The translation of B in Wiedemann, *VdDPG* 19–20, 1919, p. 666, ends here.

turn the bowl until the head of the needle that is in the middle of the bowl is opposite the north point. If it is opposite it, then the four (cardinal) directions are right according to the best approximation, as we have shown. This instrument does not require sighting the sun or the stars, but is adequate in itself, showing the meridian and all directions under a cloudless or a clouded sky, and by night and day. If you have determined the north line with it, and you next wish to determine the qibla for every locality according to the values found in the 20×20 table for establishing the qibla, and you want to determine the qibla, then you count 27 on the rim of the bowl from (the point) opposite the head of the needle—which is the north point—eastward, that is to say, twenty-seven degrees. The twenty-seventh degree is the qibla for the middle of the Yemen, for Aden, Taᶜizz and Zabīd. Then you draw a line on the ground parallel to the north point and a line from the center to the twenty-seventh degree—which is the qibla for the middle of the Yemen. Pray in that direction, because, when the north line is known, you know the qibla [145v] of every locality of the climates according to (its) deviation and according to all the surrounding degrees on the circle of the entire rim of the bowl that are associated with it. Here is the diagram of the circle you make on the rim of the bowl and the individual arguments. The diagram of the needle is in the middle.

(The diagram with the inscription follows [see fig. 1 at the end]. There are three circles; the outermost is divided into four parts marked: "south" [up], "west" [right], "north" [down], "east" [left], "qibla of Taᶜizz" [20 degrees west of north], "qibla of Aden" [20 degrees east of north]. The middle circle is divided into 72 equal parts lettered every five degrees. The innermost circle is divided into 360 parts, each degree marked with a short stroke. In the center are two lines from south to north and from east to west marked: "where the rush-like stem comes to rest in the bowl in line with [lit., opposite] the east-west line" and "where the needle comes to rest in the bowl in line with [lit., opposite] the meridian.")

The order (*tartīb*) of these notations is that you write 5 (*hāʾ*), that is, (the number) five, in the first division to the right of the north line, 10 (*yāʾ*), that is, (the number) ten, in the second division, and likewise with the remaining divisions, in the same manner, [146r] in units and tens respectively, such that the number of the last division, which is at the east line, is 90 (*ṣād*). Then you write another 90 (*ṣād*) in the division which follows it on the south side, so that the east line lies between the two 90's (*ṣādayn*). Then after the 90 you write 5, and you continue to the last division, which is next to the south line, where the number is 5. Then you write 5 in the division which is next to it, and you continue to the last division, which is next to the west line, where the number is 90. You write another 90 on the division which is next to it, so that the west line lies between the two 90's, and you continue to the last line of the section, which is at the line of the mid-heaven (*khaṭṭ wasaṭ al-samāʾ*), where (the number) is 5. All (the markings) are now complete.

Here ends the text of the two treatises on the astrolabe, the water-clock and the sundial, and the treatise on the magnetic compass concerning the determination of the qibla. We have accomplished our task to the best of our ability and after investigating the matter with the leading scholars in this field, from discussions with them and looking at the images they have drawn after the discussion, until we came to share with them the beneficial knowledge we had attained. (Only) then did we write down the operations we have recorded in this book of ours. Whoever studies it, let him not judge us too harshly. We are (only) one of those who have participated (in the search for knowledge) and not one of those who claim (to know much). We belong to those who have endeavored (to come from something known to something new), not to the speculative debaters. We ask God Almighty for assistance, increase (in knowledge)[56] and inspiration to reach our desire through His benevolence, His might, His strength and His power. He is all I need and sufficient. Herewith the treatises are concluded.

Praise be to God, to Him alone, and may His blessings and His favor be upon His messenger, our Lord Muḥammad the Prophet, and upon his family.

2.3. Commentary

The manuscript begins with the customary eulogy,[57] followed by a short summary of the subject and several paragraphs on the construction of the bowl (*ṭāsa*), the determination of the meridian (*khaṭṭ niṣf al-nahār*) and a main section on the determination of the qibla. It ends with a reference to investigations "with the leading scholars in this field" and further praise of God.

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[56] See Koran 20:113 [114].

[57] See Sellheim, article "Kitāb" in *EI*^{2}*,* p. 207b. In Welch, article "al-Ḳurʾān," 4.c. The Basmala, in *EI*^{2}*,* as well as in Gardet, article "Asmāʾ" in *EI*^{2}*,* we only find the first arrangement of the adjectives (*al-raḥmān al-raḥīm*), not the other way round, as is found in C, perhaps transposed by reason of the rhyme. To the ninety-nine most Beautiful Names of God belongs also *al-wahhāb*, the constant Giver, but not *al-wāhib* (see Gardet, article "Asmāʾ" in *EI*^{2}*,* further Flügel, *Concordantiae,* 1898, p. 216).

The description “a broad rim level (*ṣaḥīḥa*) so that (the tip of) the ruler moves on its rim evenly, like the rim (*ḥujra*) of the astrolabe” is not to be taken to mean that the compass bowl is fitted with a device like an alidade for taking magnetic bearings.[58] The text seems to introduce the ruler only in order to explain that the rim should be absolutely flat. But there are also technical problems: the cross of the needle (*ibra*) and the rush-like stem cannot support an alidade in the middle of the bowl,[59] and there is no reference to an axle or guide rails to stabilize an alidade. Further, there is no hint of an alidade in the detailed figure in the manuscript. Surely the flat and carefully divided rim suggests an alidade, but why is it not mentioned in the text, since al-Ashraf describes every detail so carefully?

In an analogy to al-Ashraf’s mention of the use of tar or wax, al-Bīrūnī, in his treatise on the construction of the astrolabe, describes a brass ring to be used as a mold for construction purposes. This ring is filled with tar or wax so that the plate laid on it is on an equal level with the rim of the ring.[60]

Al-Ashraf uses steel needles magnetized by rubbing with a magnetic stone. These needles keep their magnetic property longer than iron needles of the same size. While Gerland argues against the use of steel needles, Wiedemann is convinced that steel needles actually were in use and refers to experiments of his own on the magnetic behavior of steel nails.[61]

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[58] So Brice, *Journal of Semitic Studies* 29, 1984, pp. 169ff., quoting an unpublished text of Banerjee and Sabra.

[59] The floating compass described by Petrus Peregrinus is fitted with a device like an alidade for taking magnetic bearings, but there is a little floating box supporting the alidade (see, for example, *Rara Magnetica,* 1898, pp. 36ff. (with figure); Grant, article “Petrus Peregrinus” in *DSB,* p. 536b).

[60] *Kitāb fī ʾstīʿāb al-wujūh (al-mumkina) fī ṣanʿat al-asṭurlāb*; partly translated and commented in Wiedemann and Frank, “Beiträge LXI,” 1920–21, p. 97–121. On al-Bīrūnī, the greatest scientist of the Middle Ages, see Boilot, article “al-Bīrūnī” in *EI^2;* Kennedy, article “al-Bīrūnī” in *DSB.* On this passage see Wiedemann and Frank, *Zeitschrift für Instrumentenkunde* 41, 1921, pp. 225–36.

[61] On iron and steel production in general see Ruska, article “Ḥadīd” in *EI^1* and *EI^2,* also al-Hassan and Hill, article “Maʿdin” in *EI^2; Ullmann, Natur- und Geheimwissenschaften,* 1972, p. 114. On the magnetic properties of steel needles see Dietrich, article “Maghnāṭīs” in *EI^2,* p. 1167a; Wiedemann, “Beiträge II,” 1904, pp. 329f.; Wiedemann, *VdDPG* 11, 1909, pp. 262f. On the arguments against steel needles see Gerland, *VdDPG* 10, 1908, p. 384; Gerland, *Mitteilungen zur Geschichte der Medizin und der Naturwissenschaften* 6, 1907, pp. 15f. (in his opinion there were iron needles with a small content of steel), and on the arguments in favor of steel needles see Wiedemann, *VdDPG* 9, 1907, pp. 769f.; Wiedemann, *VdDPG* 11, 1909, pp. 265f.; Wiedemann, “Beiträge XXV,” 1911, p. 130. On experiments with

Explanations of the magnetic properties of the needle follow.[62] Al-Ashraf does not seem to know whether the end rubbed with the magnetic stone or the other one turns north, but he knows that each "head" retains its "attraction" (*ṭilba, taliba*) or "desire" to turn north or south.[63] In his comments on manuscript B, Wiedemann here understands that al-Ashraf refers to the fact that the head of the needle which is not rubbed has also changed its behavior.[64]

In the following part, on the determination of the qibla with the compass bowl, al-Ashraf first treats the determination of the north point. But there are some obscurities in the manuscript which raise questions about al-Ashraf's knowledge of the magnetic declination, that is, the deviation of magnetic north from geographical north. But how is magnetic declination to be determined? Provided the variation is sufficient,[65] a comparison between the

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steel nails similar to needles used by the Muslims see Wiedemann, *VdDPG* 11, 1909.

[62] On the knowledge of magnets and magnetism in the Islamic world in general see Dietrich, article "Maghnāṭīs," 1. The Magnetite and Magnetism, in *EI*[2], mentioning numerous legends on the magnet and its attractive power; Wiedemann, "Beiträge II," 1904, pp. 322f.; *Ullmann, Natur- und Geheimwissenschaften,* 1972, pp. 396f. See further Wiedemann, *ZP* 3, 1920, p. 141, note 1: "Mit der Wirkung des Magneten auf das Eisen und umgekehrt haben sich die muslimischen Gelehrten vielfach beschäftigt. Sie verglichen häufig dabei deren Anziehung mit derjenigen zwischen dem Liebenden und der Geliebten, ähnlich wie dies auch bei der Anziehung des geriebenen Bernsteins auf das Stroh geschah."

[63] Al-Ashraf could not say whether the needle would point south or north because he did not know in advance if the sharp or the blunt end would be aligned opposite the north. Mitchell, *Terrestrial Magnetism and Atmospherical Electricity* 37, 1932, p. 121, refers to the north-pointing needle rather in the manner of a European compass, to the south-pointing needle rather in the Chinese manner. On this topic in Europe see, for example, Taylor, *Imago Mundi* 8, 1951, pp. 1f.

[64] See Wiedemann, *VdDPG* 19–20, 1919, p. 666.

[65] A statement on the magnetic variation in the Yemen during the late thirteenth century is as yet impossible. In van Bemmelen, *Isogonen,* 1893, the variation charts begin only in 1540. In van Bemmelen, *Abweichung,* 1899, the earliest values collected go back to the second half of the fifteenth century, and a magnetic variation for Aden in 1610 is given as 12°40' W (p. 76). Dizer, *Journal for the History of Arabic Sciences* 1, 1977, p. 260, starts his values for Istanbul in 1500. Harrandon, *Terrestrial Magnetism and Atmospherical Electricity* 50, 1945, p. 68—quoting Simon Stevinus's *Portuum investigandorum ratio*—specifies values for around 1600. Finsch, *Geschichte der Magnetnadel,* 1879 gives only values for the

astronomical cardinal point observed and the direction marked by the magnetic needle will give a deviation.[66] But this observation does not have to lead to the assumption that the magnetic meridian differs from the astronomical one. The problem could be explained by the inaccuracy of the observations and the deficiency of the magnetic compass used.[67] In his text on the determination of the north point al-Ashraf always adds *bi-taqrīb* or *taqrīban*, that is, "approximately," which can reflect magnetic variation or the insufficiency of the compass bowl or the observer's incompetence.[68] More important—and more questionable—is the sentence: "This division (on the rim of the bowl) opposite the head of the needle will then represent approximately the deviation (*inḥirāf*) of the meridian (*khaṭṭ niṣf al-nahār*), which is the north point." It could refer to the magnetic variation, but not necessarily, and it could also be a *terminus technicus*. In the figure there are marks at 20 degrees east and west of the north point, which are probably not the qibla values mentioned in the text;[69] but on the other hand the cross of

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nineteenth century. The Egyptian astronomer ᶜIzz al-Dīn al-Wafāʾī (on whom see Suter, "Mathematiker und Astronomen," 1900, p. 177, no. 437; King, Survey, 1986, pp. 70ff., no. C61) determines a value for the magnetic variation for the first time in the Islamic world in the fifteenth century (Dizer, *Journal for the History of Arabic Sciences* 1, 1977, p. 260, gives al-Wafāʾī's value as 7 degrees east of north; see further Janin and King, *Journal for the History of Arabic Sciences* 1:2, 1977, p. 204, note 6; King, "L'astronomie," 1994, p. 389).

66 Using an "Indian Circle," for example, the meridian is easy to determine. Cf., for example, the description in Wiedemann, *Mitteilungen zur Geschichte der Medizin und Naturwissenschaften* 10, 1912, pp. 252f., based on a passage in the *Tafhīm* of al-Bīrūnī (trans. Wright with facsimile, London 1934), or the geometrical solution given by the same author (see Kennedy, *Mathematics Teacher* 56, 1963, and the literature there cited.).

67 On Europe see Mitchell, *Terrestrial Magnetism and Atmospherical Electricity* 42, 1937, p. 241: "For at least three hundred years before Gilbert's time, it had been noticed that the suspended magnet did not, always and everywhere, point to the exact geographical north. At first, this was explained as being due to the lodestone, by which the compass-needle was magnetised, having different properties in different parts; later on, it was attributed to imperfections in the method of magnetising the needle, or to errors in the observation of its direction relative to the geographical meridian."

68 See further Wiedemann, *VdDPG* 19–20, 1919, p. 666, note 4: "Ich glaube kaum, daß hier eine Beobachtung der Deklination vorliegt, sondern daß nur der Meinung Ausdruck gegeben wird, daß die Einstellung nicht ganz genau ist."

69 In the text al-Ashraf gives the deviation of the qibla for Aden, Taᶜizz and Zabīd as 27 degrees. On the problems relating to the qibla in this treatise see,

needle and rush-like stem is aligned in the cardinal directions. Further, there are no hints at a corrected north point in the manuscript. The most likely conclusion would seem to be that al-Ashraf did not know of magnetic variation, even if he had an idea that the magnetic needle does not point to the north point every time. The expression *inḥirāf khaṭṭ niṣf al-nahār* remains unexplained.

Before turning to the "the essential thing in determining the direction of the qibla," one remarkable term has to be discussed. Speaking of the case in which the needle is not directed to the north point, al-Ashraf uses *al-jihāt al-n-k-b*, where the verb *nakaba* can mean "to turn aside." Further it has the same root as *nakbāʾ,* meaning "a wind that blows obliquely, taking a direction between (the directions of) two (cardinal) winds."[70] At first sight it seems to make sense to equate the four cardinal directions with our four cardinal winds.[71] However, they do not correspond to them in the Islamic world,[72] and in addition the Arabs used another form of the compass card.[73]

Al-Ashraf states that qibla values should be taken from the table called *al-jadwal al-ʿishrīnī.* This qibla table contains 20×20 or 400 entries for each degree of latitude and longitude difference from Mecca from 1 degree to 20 degrees, hence the name *jadwal ʿishrīnī* (*ʿishrīn* = 20). There are two further references to 20×20 tables in medieval Arabic treatises, one in some miscellaneous notes on spherical astronomy, copied in Cairo about 1200, and another in Ibn Simʿūn's treatise,[74] which is our second source. But it is diffi-

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further, King, *ZGAIW* 3, 1986, pp. 131f.

70 See Lane, *Lexicon,* 1863–1893, 8, p. 2845, sub *n-k-b*.

71 In the *anwāʾ* traditions, the compass rose could be based on four cardinal winds (see Forcada, article "Rīḥ" in *EI²;* on the *anwāʾ* traditions in general see Pellat, article "Anwāʾ" in *EI²*).

72 See King, *Annals of the New York Academy of Sciences* 385, 1982, p. 307, fig. 2; King, *Journal of the American Oriental Society* 104:1, 1984, p. 119, and p. 120, fig. 7.

73 See, for example, de Saussure, *Archives des sciences physiques et naturelles* 5, 1923, especially p. 91 (reprint Ferrand). But al-Ashraf does not mention a compass card in his treatise. See further King, *Annals of the New York Academy of Sciences* 385, 1982, p. 309, relating to the root of *qabūl*, one of the four cardinal winds from the direction of the summer solstice, and to that of *qibla*, the direction towards Mecca.

74 See King, *Survey,* 1986, p. 192, no. Z25; King, *ZGAIW* 3, 1986, pp. 130f.: the first reference is to be found in a text preserved in MS Paris B.N. ar. 2506, fols. 42r–42v; the second reference purports to present the table itself, but a blank page (fol. 189v) follows.

cult to identify the qibla table they deal with. Possibly they refer to an Abbasid qibla table, which also contains 20×20 entries and is preserved in nine manuscripts, three of them of Yemeni provenance.[75] Al-Ashraf gives the qibla for the middle of the Yemen (Aden, Taᶜizz, Zabīd) as 27 degrees east of north. But in the figure, a mark 20 degrees west of north is referred to as *qiblat Taᶜizz* and one 20 degrees east of north as *qiblat ᶜAdan*. In his extensive astrological compendium *al-Tabṣira fī ᶜilm al-nujūm*, preserved in a single copy in Oxford, al-Ashraf gives coordinates of these localities:[76]

locality	L	φ
Mecca[77]	67;0/60;0	21;0
Aden	65;30	13;0
Taᶜizz	66;30	13;43
Zabīd	62;0	14;0

These coordinates together with several methods and tables enable us to recompute al-Ashraf's qibla values.[78] The first of the following tables gives the values according to al-Ashraf's treatise on the magnetic compass. The quadrant of the deviation is given because the Oxford manuscript has two values for the longitude of Mecca (L_M), and the geographical longitudes of Aden, Taᶜizz and Zabīd are between the two.

	Aden	Taᶜizz	Zabīd
text	27 NE	27 NE	27 NE
figure[79]	20 NE	20 NW	—

[75] See King, *ZGAIW* 3, 1986, pp. 118ff.

[76] These cities are listed in a geographical table in the last part of the treatise. After Mecca, Aden, Sanᶜāᵓ, Taᶜizz, and Zabīd follow another 40 cities. On this manuscript, Bodleian Huntington 233 (Uri 905), and its contents, see Suter, "Mathematiker und Astronomen," 1900, p. 161, no. 394; King, *MAY,* 1983, p. 28; Varisco, *Manuscripts of the Middle East 4,* 1989, p. 152; Varisco, *Almanac,* 1994, especially pp. 16ff. On the geographical coordinates see King, *ZGAIW* 3, 1986, p. 132.

[77] The two values for the longitude of Mecca are based on a note in the manuscript inserted after the first value saying that several manuscripts have the more correct value 60 degrees (see, further, King, *ZGAIW* 3, 1986, p. 132).

[78] For an overview of early methods and tables for finding the direction to Mecca, see King, *ZGAIW* 3, 1986, pp. 82ff.

[79] Labels are marked as *qiblat Taᶜizz* and *qiblat ᶜAdan.*

The second table gives the calculated values of the qibla according to the correct modern formula[80] and according to two approximate methods. The first of the approximations uses recomputed values based on a standard approximate method, and the second uses the Abbasid qibla table mentioned above:[81]

	L_M	Aden	Ta^cizz	Zabīd	L=63;30 φ=14;30
calculation	60;0	32;33 NW	39;30 NW	14;57 NW	—
	67;0	09;57 NE	03;41 NE	33;33 NE	—
approximation (first method)	60;0	34;29 NW	41;45 NW	15;59 NW	—
	67;0	10;37 NE	03;56 NE	35;34 NE	—
approximation (second method)	60;0	32;44 NW	39;55 NW	14;57 NW	26;54 NW
	67;0	09;55 NE	03;40 NE	33;45 NE	—

The values of the deviation taken from the figure correspond neither with the values given in the manuscript nor with any of the calculated values. Nor can approximative methods explain the value of 27 degrees east of north given by al-Ashraf. But one explanation is possible. Earlier in al-Ashraf's text, in his treatise on the sundial, which precedes the treatise on the magnetic compass,[82] the author also gives a qibla for the Yemen of 27 degrees and a fraction, but without mentioning the quadrant. He uses for Mecca a longitude of 60;0 and for the Yemen of 63;30.[83] For these values and an assumed latitude of 14;30,[84] approximately the value given in the treatise on

[80] The modern formula is

$$q = arc\cot\left\{\frac{\sin\varphi\cos\Delta L - \cos\varphi\tan\varphi M}{\sin\Delta L}\right\}$$

with q: deviation (*inḥirāf*), φ: latitude, φM: latitude of Mecca, ΔL: difference of the longitudes.

[81] On the first approximative value see the table in King, *ZGAIW* 3, 1986, pp. 108f., and on the second, the table pp. 120f. Values with fractions of degrees are calculated by linear interpolation, for ΔL=0 is assumed q=0.

[82] C, fol. 143r.

[83] C, fol. 143r, writes "latitude" for the middle of the Yemen instead of "longitude," as do T_1, p. 158, and T_2, p. 2.

[84] These are exactly the coordinates underlying al-Fārisī's tables in his *Zīj al-Muẓaffarī* (see Lee, *Transactions of the Cambridge Philosophical Society* 1, 1822, p. 260). There are further relations between al-Fārisī and al-Ashraf. Al-Fārisī was an

the magnetic compass is obtained—however in the wrong quadrant. This could be explained by the lack of the quadrant in the earlier passage, and it provides an explanation for the values in the diagram as well. The copyist was not aware which quadrant was the right one.

In the final paragraph of our text the scope of the entire work is mentioned: the two treatises on the astrolabe, the water-clock and the sundial and the treatise on the magnetic compass concerning the determination of the qibla. This makes it clear that the treatise on the magnetic compass is part of the main astronomical work.

Al-Ashraf concludes with the remark that he had put forth his best efforts in writing the treatise and had consulted "the leading scholars in this field." It is difficult to imagine that he did not also consult an earlier treatise on the magnetic compass.

To sum up, while the earliest known sources on the magnetic compass in the Islamic world describe its use at sea, in al-Ashraf's treatise on the construction of astronomical instruments, written at the end of the thirteenth century, the compass has an entirely different function. We can not

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astronomer at the Rasulid court and dedicated his *zīj* to al-Ashraf's father, the sultan al-Muẓaffar; and in al-Ashraf's astrological compendium *al-Tabṣira fī ᶜilm al-nujūm* there are correspondences to al-Fārisī's folk astronomical treatise *Tuḥfat al-rāghib wa-turfat al-ṭālib fī taysīr al-nayyirayn wa-ḥarakāt al-kawākib*, for example, the very similar qibla schemes. See, in general, King, *MAY,* 1983, p. 23. On the author see especially Brockelmann, *GAL,* 1943, 2, p. 474, and *S,* 1, p. 866f.; Suter, "Mathematiker und Astronomen," 1900, p. 218, note 72, and "Nachträge," p. 175, no. 349 On the *Zīj al-Muẓaffarī* see Kennedy, *Survey,* 1956, p. 132, no. 54; Lee, *Transactions of the Cambridge Philosophical Society* 1, 1822, pp. 249ff.; Ḥibshī, *Maṣādir,* n.d., p. 483; on the *Tuḥfa* see Hawkins and King, *Journal for the History of Astronomy* 13, 1982, pp. 102ff.; on the manuscript [Milan, Ambrosiana X 73 sup.] see Löfgren and Traini, *Catalogue,* 1975, p. 142, no. CCLXX A; on the qibla scheme see King, article "Makka, 4. As the Centre of the World," in *EI²,* p. 183b and fig. 4.

See further King, *ZGAIW* 3, 1986, pp. 131f.: "Al-Ashraf himself in the treatise on the compass states that the qibla for the central Yemen (Aden and Taiz) is 27 degrees east of north, without giving any details about the geographical coordinates with which this value was derived, but implying that it was taken from a *jadwal ᶜishrīnī*. However, some notes at the end of this treatise (fol. 143r) state that the qibla is 27° 'and a fraction' east of north, and that this value is for the Yemen with L=63;30° and Mecca with L=60;0°. Now, if we assume that φ=14;30°, which is one of the values used by al-Ashraf for the Yemen, and enter in the table with arguments Δφ=6;30° and ΔL=3;30°, then using linear interpolation between the values: we obtain q=26;54."

only determine the meridian under any weather conditions and at any hour of day or night, but we can also use it as a basis for the determination of the qibla. Furthermore, al-Ashraf's treatise constitutes on the one hand the first reference to the magnetic compass in an astronomical work[85] and on the other the first full description of its construction in the Arabic sources known to us.

3. Ibn Sim^c^ūn's treatise

A treatise on time-keeping written about 1300 by an Egyptian astronomer and muezzin called Ibn Sim^c^ūn contains a chapter on the magnetic qibla indicator which is our second source. It is based mainly on the work of Abū ^c^Alī al-Marrākushī, who compiled a compendium of spherical astronomy and astronomical instruments, which is perhaps the most valuable single source for the history of Islamic astronomical instrumentation,[86] as well as on the *Muṣṭalaḥ zīj*, the most popular *zīj*—as medieval Islamic astronomical handbooks are called—in medieval Egypt.[87] Only one copy of Ibn Sim^c^ūn's treatise, preserved in the Universiteitsbibliotheek Leiden (Or. 468, 192 fols.), is known. The work is entitled *Kanz al-yawāqīt fī ᵓstīᶜāb al-mawāqīt*. Fol. 190r contains the "Chapter on the Use of the Qibla Instrument for Every Locality."[88] This source is henceforth labeled L.

The Arabic text given here is provided with hamzas and diacritical points. On the punctuation and use of parentheses, see above.

3.1. Arabic text

الفصل في عمل آلة القبلة لأي بلد شئت بواسطة المغناطيس وصفة الكعبة وذكر جدول يشتمل على انحراف قبل جملة من البلدان وجهة الربع الذي فيه

[85] See King, "L'astronomie," 1994, p. 389; King, *ZGAIW* 2, 1985, p. 112; King, *MAY,* 1983, p. 29.

[86] On the author see King, article "al-Marrākushī" in *EI*^{2}. Al-Marrākushī's compendium of spherical astronomy and astronomical instruments *Kitāb Jāmiᶜ al-mabādiᵓ wa-ᵓl-ghāyāt fī ᶜilm al-mīqāt* was edited by father and son Sédillot (Sédillot, *Traité des instruments astronomiques,* 1834–35, contains the first part on spherical astronomy and sundials; Sédillot, "Mémoire sur les instruments," 1844, summarizes the second part on astronomical instruments).

[87] On zījes see in general Kennedy, *Survey,* 1956. On the *Muṣṭalaḥ zīj,* see idem, p. 131, no. 47; King, *Isis* 74, 1983, pp. 535f.

[88] See Voorhoeve, *Handlist,* 1957, p. 153, who gives 282 folios; King, *ZGAIW* 3,

القبلة من أي أرباع الأفق

اعلم أن العمل بالمغناطيس لم نجده لأحد من متقدمي هذه الصناعة ، واشتهر عند جماعة من المتأخرين ، سيما في زماننا هذا . ولم يذكره المراكشي في مبادئه وغاياته وهو من ملح هذا العلم لا من متينه ، والاعتماد عليه خطر لجواز سلب خاصيته ولسرعة تغير التريس الذي يدور عليه آلة القبلة لكثرة توقفه .

ولم يختلفوا في أن لا يتوقف بحق من زجاج فلم يقد ، ومن فضة فكذلك ومن بلور قانئ ، إلا أن يستنكر ويقف . ولذلك أهمله الأولون للعلتين المذكورتين . ولنصف عمل آلته واستخراج القبلة بها على رأي المتأخرين القائلين بالملح ونقول ، وبالله التوفيق

صفة عمل آلة القبلة أن تعمل شكلا مدورا من ورق متماسك أو قرع ونحوهما . تقسم محيطها بشس درجة وتخط ما تختاره من محاريب البلدان بحسب ما يقتضيه انحرافه متميزا بكتابة تدل عليه . وقد تجعل في بعضها بسيطة لعرض مخصوص بشخص لطيف لائق بهذه الآلة بحسب كبرها وصغرها . وتوضع في جنبها قطعة مغناطيس ، إما على خط نصف النهار أو منحرفا عنه إلى الجهة التي أردت إليه التحرمة بقدر انحراف ذلك المغناطيس عن الخط ، ويوضع في ظهرها إبرتين [كذا] لزنتها ، وقد يجعل في وسط الآلة شكل الكعبة المعظمة . وتجعل هذه الآلة على شكل تريس من زجاج أو نحاس أو غيرهما ، وكلما كان دوران الآلة بسلاسة من غير عسر كان أوفق . ويجعل ذلك على إبرة مغروزة في حق من أبنوس أو نحاس أو

1986, p. 131.

غيرهما بحسب ما تختار مطالبها . ويجعل على فم الحق جام من زجاج المرايا يرى منه وقوف المحراب المرسوم المطلوب حال تحريكها في جهة القبلة . كلما قل وزن الجانب من المغناطيس مع كثرة وزن المحراب كان ذلك المغناطيس مقدما على غيره من أجناس المغناطيس . وليجتنب الثوم فإنه يبطل خاصيته وتعود خاصيته بغمس المغناطيس في دم عنز ، والله أعلم .

The diagrams with the inscriptions follow. There are two figures, on the right hand side the qibla instrument, labeled: *wa-hādhihi ṣūrat al-ḥuqq al-madhkūr* (headline), *al-jām al-muṭabbaq ᶜalā fam al-ḥuqq* (above), *dhāt al-maḥārīb* (center), *al-turays* (below, left side), *al-ibra* (below, right side), *ṣifat al-ḥuqq* (right). The second figure, on the left hand side, is the disk with the Kaaba provided with the cardinal points, in the center the Kaaba: *wa-hādhihi jadāwil maḥārīb jumla min al-buldān bi-ḥasab istidāratihā ḥawla ᵓl-Kaᶜba fī dhāt al-maḥārīb* (headline, repeated under the figure). *Al-jadwal al-awwal fī ᵓnḥirāf maḥārīb al-buldān allatī ᵓl-Kaᶜba minhā sharqīya janūbīya* (headline of the following table).

3.2. Translation

Chapter on the Use of the Qibla Instrument (*ālat al-qibla*) for every locality you wish by means of the magnet, the description of the Kaaba and a table which contains the qiblas (*inḥirāf al-qibal*) for a number of localities and the direction of the qibla in any given horizon quadrant.

Know that we have not found (a description of) the use of the magnet by any of the early (scholars) of this discipline, although it is well known amongst a number of more recent (scholars), especially in our own time. Al-Marrākushī did not mention it in his *(Kitāb jāmiᶜ) al-mabādiᵓ wa-ᵓl-ghāyāt (fī ᶜilm al-mīqāt)*. (The use of the magnet) belongs to the diversions (*milḥ*) of this science, not to its core (*matīn*). Reliance on it is dangerous, because of (the possibility) of the loss (*salb*) of its sympathetic qualities and because of the quickness with which the cone (*turays*) changes on which the qibla instrument turns, owing to its considerable hesitating motion.

(Scholars) are in agreement that it does not display hesitating motion in a glass container nor is it led (*fa-lam yuqad*), nor does it do so in (a container) of silver, nor in one of deep-red crystal (*billawr qāniʾ*),[89] for (in all these cases) it recoils (*yastankir*) and stops. Therefore the early scholars neglected it, because of the two problems we have mentioned. Now let me mention of the construction of the instrument and how one uses it to determine the qibla according to the opinion of those more recent scholars who are concerned with the diversions (of our science). We say, and with God is success:

The manner in which the qibla instrument is contracted is that you make a round form of paper pasted together (*waraq mutamāsik*) or *qarʿ*[90] or the like. You divide its circumference into 360 degrees, and you mark (the direction of) the prayer-niches of the localities you choose, according to their qibla, distinguished by an inscription indicating the locality. Sometimes a horizontal sundial (*basīṭa*) for a specific latitude is made on some of these with a little gnomon (*shakhṣ laṭīf*), appropriate to this instrument in accordance with its size.[91] A piece of magnet is put on its side, either on the meridian or inclined from it in the direction in which you want to perform your religious obligations (*al-jiha allatī aradta ilayhā al-taḥrima*), according to the deviation (*inḥirāf*) of the magnet from the line (of midday). Two needles (*ibratayn*) are put on its back in order to balance it. Sometimes a diagram of the exalted Kaaba is made in the middle of the instrument. This instrument is put on something like a cone of glass or brass or other material. The smoother and freer the rotation of the instrument the better (the material). (Then) this is put on a needle implanted in a box of ebony or brass or other material as may be appropriate. A lid (*jām*) of mirror-glass is put on the opening of the box, through which one can see when the decorative prayer-niche stops, which is what is intended when it is moved in the direction of the qibla (*yurā minhu wuqūfu ʾl-miḥrābi ʾl-marsūmi ʾl-maṭlūbu ḥāla taḥrīkihi fī jihati ʾl-qibla*). The less the weight of the attractive (ele-

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[89] On rock crystal see Ruska [C. J. Lamm], article "Billawr" in *EI²;* see further Wiedemann, "Mineralogie," 1927, p. 53, mentioning the construction of glass (*zujāj*) and rock crystal (*billawr*) vessels.

[90] The material first mentioned in the manuscript is a sort of pasteboard; *qarʿ* properly means "pumpkin" (see Ullmann, *Natur- und Geheimwissenschaften,* 1972, pp. 264f., translating with "Cucurbit [i.e. pumpkin]; flask"). This material is indeed connected with the making of a floating compass (in al-Zarkhūrī's treatise); probably it is a sort of wood.

[91] This device reminds one of the European compass-sundials (see, for example, Zinner, *Instrumente,* 1956, 1, pp. 92f.; Körber, *Sonnenuhren und Kompasse,* 1965, pp. 14ff.; Chandler, *Metropolitan Museum Journal* 2, 1969; Bobinger, *Alt-Augsburger Kompaßmacher,* 1966, pp. 26ff.).

ment) of magnetic material and the greater the weight of the prayer-niche, the higher the quality of that particular kind of magnet. Let garlic be kept away (from the magnet), for it neutralizes its sympathetic qualities. But these are restored by dipping the magnet in goat's blood.[92] And God knows best.

(The diagrams with the inscriptions follow [see fig. 2 at the end]. There are two figures, on the right side the qibla instrument labeled: "This is the diagram of the box mentioned" [headline], "the corresponding lid placed above the opening of the box" (*al-jām al-muṭabbaq ᶜalā fam al-ḥuqq*) [above], "the prayer-niches" [center], "the cone" [below, left], "the needle" [below, right], "description of the box" [right]. The second figure, on the left hand side, is the disk with the Kaaba labeled with the cardinal points, in the center the Kaaba. The headline repeated under the picture reads: "These are tables of prayer-niches for a collection of localities according to their place on a circle around the Kaaba on the prayer-niche scale in this figure." The headline of the table that follows[93] reads: "The first table of the qiblas of the prayer-niches of the localities for which the Kaaba is in the south-east.")

3.3. Commentary

The "Chapter on the Use of the Qibla Instrument" includes construction of the qibla indicator, a description of the Kaaba and a table of the deviation of qiblas (*inḥirāf al-qibal*). The name used for the instrument described (*ālat al-qibla*) is remarkable in that it is not determined only by its form but by its purpose, namely, to indicate the qibla.

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92 This topic appears frequently in antique and medieval Arabic and Latin sources (see Ullmann, *Natur- und Geheimwissenschaften,* 1972, p. 398, referring, for example, to Demokritos, ᶜAlī ibn Rabbān, Jābir and al-Bīrūnī). Dietrich, article "Maghnāṭīs, 1. The Magnetite and Magnetism," in *EI*²—giving the Arabic sources (among others al-Qazwīnī and al-Dimashqī)—mentions among the substances that diminish the power of the magnet the spittle of a fasting man and onions, and among those that enhance it the blood of a freshly-slaughtered he-goat. The dipping in goat's blood is also found in al-Ḥusnī (see Siggel, *QSGNM* 8, 1941–42, p. 443; Wiedemann, *ZP* 13, 1923, p. 114). For Europe Balmer, *Geschichte des Erdmagnetismus,* 1956, p. 44, mentions among others Marbodaeus Gallus referring to the enhancing effect of the he-goat's blood on a magnet's power, and Albertus Magnus, Matthiolus and Georg Agricola citing the vitiating effect of garlic.

93 A table with qibla values follows on the next two pages. It is merely a list of names of localities and the associated qibla values; the geographical coordinates are missing.

The first substantive section of the passage begins with a short general introduction on the directive power of the magnetic stone. The statement that the use of the magnet is not known to "any of the early (scholars) of this discipline, although it is well known amongst a number of more recent (scholars)," agrees with our assertion that the magnet's directive power was unknown in Antiquity but was known later in the Islamic world. The author specifically mentions al-Marrākushī, the major contemporary for astronomical instruments, who does not mention the use of the magnetic compass in his opus magnum.

Two flaws of the magnetic compass are described: loss of magnetic properties and attrition of the cone (*turays*).[94] Because of these two flaws "the early scholars" (*al-awwalūn*) did not use the magnetic compass and probably in the opinion of the "more recent" scholars (*al-mutaʾakhkhirūn*) it belonged to the diversions of the subject (*milḥ*). Unfortunately, neither group has been identified. But it is remarkable that this statement refers to the earlier knowledge of a dry compass.

The second section of the passage contains instructions for the construction of the qibla indicator. The construction of the round plate is more or less clear, but the materials described as "paper pasted together" (*waraq mutamāsik*) and "pumpkin" or "gourd" (*qarʿ*) are a problem. They should be firm and light in weight. This is all we can say. Three further matters arise within the next few lines. Firstly, is the piece of magnetic stone fixed upon the round paper plate or used to magnetize the needles (*ibratayn*) mentioned later? Secondly, is "the direction in which you want to perform your religious obligations (*al-jiha allatī aradta ilayhā al-taḥrima*)" an unusual way of referring to the qibla with some sort of *miḥrāb* indicating the direction towards Mecca? Thirdly, does the author know of the magnetic declination when he speaks of "the deviation of the magnet from the line (of midday) (*inḥirāf dhālik al-maghnāṭīs ʿan al-khaṭṭ*)?"[95] As mentioned above, in the commentary on al-Ashraf's treatise, knowing that the needle does not point to the true north-south line is not necessarily the result of an observation of the magnetic declination.

Especially difficult to understand is the word "cone" (*turays*), which is written without diacritical points in the manuscript. As yet I have been able

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[94] See below on this page and the following, and note 96, on the possible meaning of the word *turays*.

[95] No statement is yet possible on the magnetic variation in Egypt during the middle of the fourteenth century. See further above, note 65, where some early values with references are given.

to find no reference for it.[96] But the author himself provides some clues. Firstly, "reliance on it (the compass) is dangerous, because . . . of the quickness with which the cone (*turays*) changes on which the qibla instrument turns, owing to its considerable hesitating motion." Secondly, "this instrument is put on something like a cone of glass or brass or other material. The smoother and freer the rotation of the instrument the better the material." Thus it is likely that the cone was thought to be something like a little plate or dome fixed under the round plate of paper in order to diminish the friction between the plate and the needle implanted in the box. This seems to be similar to al-Zarkhūrī's description of a dry compass.[97] A comparison between the Arabic texts of al-Zarkhūrī and Ibn Simᶜūn could provide further information, especially regarding vocabulary.[98]

The treatise of the Egyptian Ibn Simᶜūn thus provides the earliest evidence of a dry compass in the Islamic world. In the headline the author uses *ālat al-qibla* for his instrument rather than any of the several terms known to us from medieval Arabic sources (*ḥuqq al-qibla*, *ṭāsa, ḥikk*, *bayt al-ibra*[99]). He explains the purpose of the instrument at the beginning. Some aspects of the construction are only implicit in the text, but the introduction and the end clearly indicate that the author is familiar with the traditions of the magnetic stone. Apart from al-Zarkhūrī this qibla indicator can also be compared with the *ṣandūq al-yawāqīt* of Ibn al-Shāṭir, which is an astronomical "compendium"[100] from the second half of the fourteenth century, on the construction

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[96] My reading *turays*, the diminutive of *turs*, is based on Wiedemann, *Nova acta* 100:5, 1915, p. 211, who interprets *turs* as a part of a clock—also an instrument. Ibn Mājid in any case renders this part of the magnetic compass by *qubba,* or "dome" (see Tibbetts, *Arab Navigation,* 1971, p. 293). In another passage Ibn Mājid describes the use of the lodestone over the compass-box by *tartīb al-maghnāṭīs ᶜalā ʾl-ḥuqqa* (see Tibbetts, *Arab Navigation,* 1971, p. 292)—in Arabic the orthography of the word *tartīb* is rather similar to *turays.*

[97] On al-Zarkhūrī see above. Wiedemann renders this cone in his article on al-Zarkhūrī's text with "Trichter," or "funnel."

[98] A further problem is that the text does not explicitly mention a marking outside the round form, for example, on the box to orientate the magnetic needle correctly (observation for which I am indebted to Dr. Helga Dittberner, Frankfurt).

[99] See further Wiedemann, article "Maghnāṭīs, 2. The Compass," in *EI*[1] and *EI*[2], p. 1169a. The passages, given only in translation, are not reproduced (for example, Wiedemann, *VdDPG* 9, 1907, p. 766, renders the term for the vessel used by ᶜAwfī with the German word "Teller," or "plate").

[100] On Ibn al-Shāṭir and his instrument, see above.

and use of which two manuscripts are preserved.[101] The magnetic compass fitted with the instrument is now lost. In the two texts about the instrument the compass is called south-pointer (*murī al-janūb*).[102] There are only general hints at the construction of the compass, and these are not sufficiently detailed to make possible a comparison with Ibn Simᶜūn's qibla indicator.

4. Summary

The importance of the two treatises discussed here lies in the description of the determination of the qibla by means of the magnetic compass. To this day al-Ashraf and Ibn Simᶜūn are the earliest textual sources we know for this religious use of the directive power of the magnet. The Yemeni Sultan al-Ashraf, at the end of the thirteenth century, describes a floating compass mentioned also by other authors, but he gives detailed information on its construction and use. His text is an integral part of an astronomical treatise, the first reference to a floating compass in a medieval Islamic scientific treatise. The Egyptian astronomer Ibn Simᶜūn describes another kind of qibla indicator, a dry rather than a floating compass, with specific markings. His is the earliest known reference to this instrument in the Islamic world.

Nearly a century ago, Wiedemann, referring to ᶜAwfī and al-Zarkhūrī, stated that the Arabs were aware of magnetizing by rubbing with a magnetic stone at the beginning of the thirteenth century, that it was known that iron with a content of steel may be made into a permanent magnet, that the technique was practiced in the fourteenth century, and that the magnetic compass was in general use.

> Die mitgeteilten Stellen zeigen, daß man bei den Arabern schon am Anfang des 13. Jahrhunderts die Magnetisierung durch Streichen kannte und daß man diese auch im 14. Jahrhundert im Orient anwandte. Beide Stellen zeigen auch, daß bekannt war, daß das stets etwas stahlhaltige Eisen dauernd magnetisch wurde, und daß diese Erscheinung experimentell geprüft wurde; ferner, daß zu dieser Zeit der Kompaß allgemeine Anwendung fand. (Wiedemann, 1907)[103]

Now we can add that the use of the magnetic compass in the service of

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[101] MS Berlin Ahlwardt 5845, fols. 1r–2v and 4r–7r (according to Janin and King, *Journal for the History of Arabic Science* 2:1, 1977, pp. 191, 196).

[102] On *murī al-janūb*, also *mūrī al-janūb* see Janin and King, *Journal for the History of Arabic Science* 2:1, 1977, p. 195, in the appendix pp. 243, 247; on the construction pp. 192, 204; on the use pp. 195f., 204, 209.

[103] Wiedemann, *VdDPG* 9, 1907, p. 773.

religion is attested in two medieval Arabic treatises, and in two different varieties: one floating, described by a Yemeni astronomer-prince, and one dry, described by an Egyptian mosque astronomer, both writing around 1300.

5. Appendix

5.1. Glossary [104]

Arabic	English	Source
أبنوس ، آبنوس	ebony	L
أفق	horizon	L
إقليم – أقاليم	clime (in the sense of classical geography), also region	C
آلة القبلة	qibla instrument, qibla indicator	L
بسيطة	horizontal sundial	L
بلور قانئ	deep-red crystal	L
بيكاز	(geometrical) compass	C
تبن	straw	C
ترجهار	water-clock	C
تريس	little shield; cone, dome, funnel	L
جام	vessel; lid	L
جدول – جداول	table	L, C
حجرة	outer rim of the astrolabe	C
انحراف (القبلة)	angle between the meridian of any localitiy and the great circle passing through this locality and Mecca	L, C
خاصة – خواص	sympathetic qualities, *virtus*: describing an inexplicable force inherent in animate and inanimate nature	L, C
خط نصف النهار ، خط وسط النهار	line of midday, meridian	L, C
خط وسط السماء	line of the middle of the heaven, meridian	C
درجة – درج	degree	L, C
رخامة	sundial	C
زيغ	divergence	C
زجاج	glass	L

[104] There is no vocalization in the texts.

Arabic	English	Source
سلاسة	tractability; something being or becoming smooth	L
مسامة	being opposite, facing	C
سمارة	sort of blade (of rush?)	C
شخص	gnomon	L
شمع	wax; candle	C
طاسة	bowl, drinking vessel; magnetic compass bowl	C
فضة	silver	L, C
فولاذ ، بولاذ	steel, cleaned and improved iron	C
قار ، قير	pitch, tar	C
قبلة – قبل	qibla, the sacred direction of Islam towards Mecca	L, C
قرع	pumpkin	L
قسمة – قسم	part, portion	C
قشة	blade	C
مغناطيس ، مغنطيس ، مغنيطيس	magnet, magnetic stone; magnetism	L, C
ميل	deviation, declination (astron.)	C
نحاس	copper; brass	L, C
نكباء – نكب	wind, blowing from a direction between two of the cardinal directions	C

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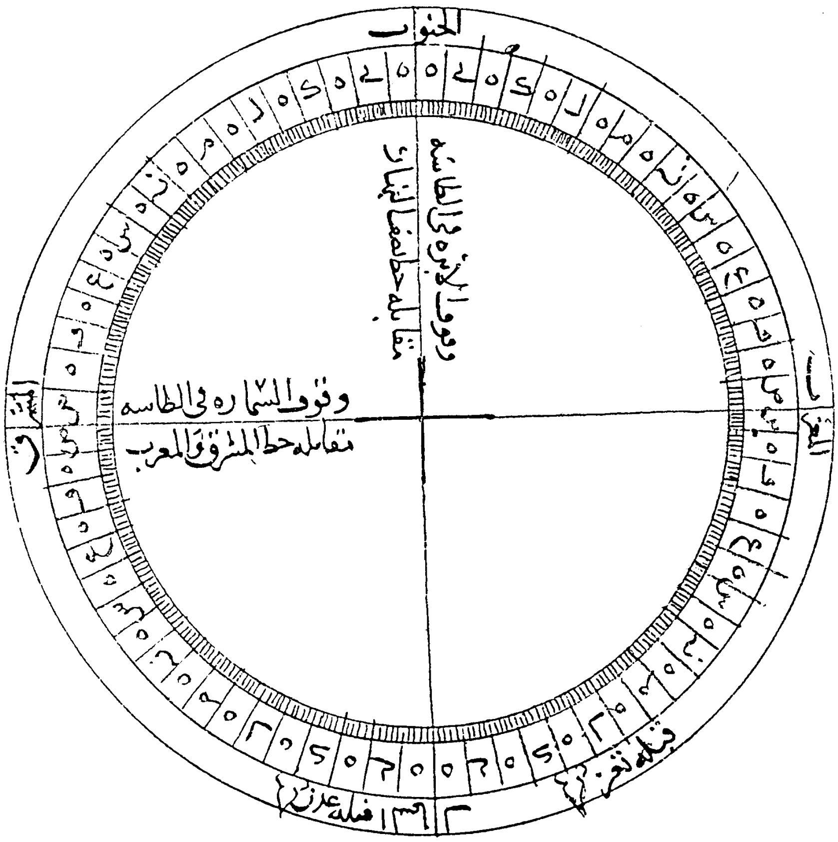

Fig. 1. Al-Ashraf's diagram of the compass bowl (taken from MS Cairo TR 105, fol. 145v; courtesy of the Egyptian National Library).

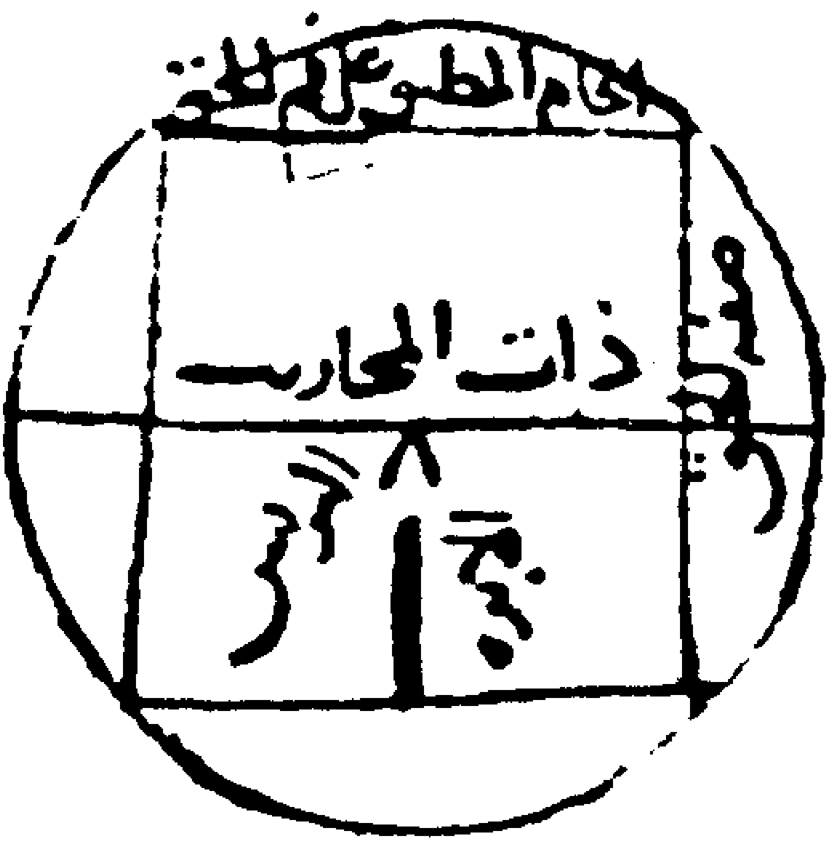

Fig. 2. Ibn Simᶜūn's qibla indicator (taken from MS Leiden Or. 468, fol. 190r; courtesy of the Universiteitsbibliotheek).