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COBALT

COBALT (*sang-e lājavard* "blue stone," also applied to lapis lazuli and ultramarine; *lājavard-e kāšī* "ceramic blue"; *lājavard-e solaymānī* "Solaymān blue"), a chemical element that imparts a blue color to glass and glazes and to certain pigments. The term *lājavard* actually refers to lapis lazuli (e.g., *lājavard-e aṣl* "genuine lapis lazuli," *lājavard-e badaḵšī* "lapis lazuli from Badaḵšān") but was applied to cobalt ores and smalt (see below) because their blue color is close to that of lapis lazuli; *lājavard-e farangī* ("European blue") refers specifically to smalt.

Cobalt as a pigment. The term "cobalt blue" is usually used in English to describe a deep blue color when the actual source is unknown. In addition, there is a modern pigment known as "cobalt blue," cobalt aluminate, which was first manufactured in Europe in 1802 (Gettens and Stout, 1966, p. 108) but has been identified on painted pottery from Egypt of the 14th century b.c.e. (Riederer, pp. 104-06). Smalt is an artificial blue pigment with a history closely related to that of blue glass and glazes. It is a powdered potassium glass, moderately to coarsely ground and tinted blue with a small amount of cobalt. It was used by European artists as early as the 15th century but has been identified in earlier paintings from Asia (Mühlethaler and Thissen, pp. 47-49): 11th-13th-century wall paintings from the Central Asian site of Kara Khoto, a Chinese wall painting of the Ming dynasty (1368-1644; Gettens and Stout, 1966, p. 108), and 14th-century murals in a Byzantine church (Kariye Cami) in Istanbul (Gettens and Stout, 1958, p. 113). Japanese artists used it in paintings on paper and silk as early as the 16th century (FitzHugh, 1979, pp. 30-33).

Cobalt blue and smalt have not so far been reported among pigments used in Persian manuscript illustrations or wall paintings (FitzHugh, 1988).

Cobalt in glass and ceramics. Blue glass and blue ceramic glazes colored with cobalt have also been identified from a wide geographical area. Various cobalt compounds were used for this purpose, among them cobalt oxide (Ger. *Zaffre*) and smalt. The first recorded European production of cobalt compounds for coloring ceramic glazes was in 15th-century Saxony (Mühlethaler and Thissen, p. 47), but again such uses already had a long history in Asia. The earliest known object containing cobalt is a blue glass lump dated to about 2000 b.c.e. from the site of Eridu, in southern Mesopotamia (Garner, 1956, pp. 147-49). Cobalt has also been identified in blue glass from Egypt of the late 16th century b.c.e. (early Eighteenth Dynasty; Farnsworth and Ritchie, pp. 158-61), from the Aegean area at about the same date, and from Roman Pompeii and Syria (Sayre, pp. 4-11), as well as in late Parthian beads from northern Persia (Oda, p. 46). The Chinese were coloring blue glass with cobalt under the Chou dynasty (1122-221 b.c.e.; Ritchie, p. 219). The earliest Chinese cobalt glazes date from the T'ang period (618-907 c.e.; Gettens, p. 29), but perhaps the best-known use of cobalt on Chinese ceramics is the underglaze-blue decoration on blue-and-white ware of the Yüan (1279-1368) and Ming (1368-1644) dynasties (Young, pp. 43-47). There is some evidence that Persia may have been a source of cobalt for Chinese ceramic glazes. A material called *su-lai-man* by the Chinese (Pers. *solaymānī*) was imported into China in the 15th century; a coloring material sometimes ambiguously translated from the Chinese as "Moḥammadan blue" was also available (Watt, pp. 69, 72, 81). In India the blue glazes on 16th-century tiles from Bihar and on late Mughal tiles have been found to be colored with cobalt (Lal, pp. 244-46).

Cobalt in Persia. Identifications of cobalt in Persian blue glass and glazes are relatively few, but it is generally assumed that a deep blue color, usually identified as "azure" by early European travelers, betrays its presence, whereas greenish or turquoise blue is usually owing to the presence of copper. According to modern mineralogical literature, there are extensive deposits of cobalt ores in Azarbaijan (Palache et al., pp. 296-98), at Qamṣar, near Kāšān (Ladame, pp. 195-97), and at the small towns of Meskānī and Talmesī about 30 km west of Anārak; there are lesser deposits at Emāmzāda Dāʾūd near Tehran and Berenjīkī in Baluchistan (Harrison, pp. 513-14). Cobalt ores are also found at the Ketri mines in Rajputana, India (Palache et al., pp. 296-98). The evidence from Mesopotamia and China suggests that Persia was the chief source of

cobalt ores in the ancient world until the late Middle Ages; although there are also minor cobalt deposits in the western desert of Egypt south of Cairo, they were probably not exploited in antiquity (Kaczmarczyk and Hedges, p. 52).

In 700/1301 the potter Abu'l-Qāsem described the techniques and materials used in Persian ceramics (Allan). The material used to color the glazes blue came from a stone called *lājavard*, which was found near Qamṣar (cf. Allan, pp. 112, 116-17). The same term also referred to lapis lazuli, a quite different blue material (see above), and, according to a later marginal note in the author's autograph manuscript, cobalt was used to make an imitation of lapis lazuli (Abu'l-Qāsem, fol. 20r; Allan, p. 120), that is, blue glass. Judging from Abu'l-Qāsem's report, the cobalt ore was probably cobaltite (cobalt arsenic sulfide), a silver-white mineral, sometimes with a reddish cast but often black if iron is present. He also described cobalt bloom, the mineral erythrite (a cobalt arsenic oxide), which weathers out from cobalt ore as bright red masses of fine needles, and another material, evidently from Europe. It may be that at an early date cobalt ores reached Asia from Saxony, which was the only major European source of cobalt until it was discovered in Sweden in 1790 (Taylor, pp. 5-6). Both these ores have, however, been identified at Qamṣar in modern times (Ladame, pp. 195-97). Mention of a third material, from Farangestān (Europe; Allan, pp. 112, 117), suggests that Saxony may have been producing, and shipping, cobalt ores at a date considerably earlier than has otherwise been recorded. This conclusion seems to be supported by a report from John Fryer, who noted in 1672 that the Persians made azure with "the German Stone" (III, p. 10), and by the fact that smalt is known in Persian as *lājavard-e farangī* (Schlimmer, p. 70). Hans Wulff (*Crafts*, p. 120) noted that relatively small amounts of cobalt ores are required to produce a blue color and suggested that they could have been traded to Persia from sources other than Kāšān at an early date, but he did not specify what those sources might have been.

Cobaltite was still being mined at Qamṣr in the 19th century: "Cobalt (*ḵāk-e lājavarḍ . . .*) is found in considerable quantities near Kāšān in the village of Qamṣar. The mine is the property of a *sayyed* family. Significant amounts of cobalt ore are said to be exported to Russia" (Polak, II, p. 177). ʿAbd-al-Raḥīm Żarrābī, who completed his history of Kāšān in 1288/1878, described the prominent local family of "Lājavardī *sayyeds*" who owned the Qamṣar mines and leased them to the operators (p. 226). In 1874 Schlimmer reported that ore from the mines near Kāšān was lacking in the iron pyrite that produces gold

"veining." According to him, *lājavard-e kāšī* was mined as lumps of dark-gray earth, from which a compound of mineral and gangue mixed with water was made and distributed equally among 200 shareholders; mining was then suspended, sometimes for several years, until all the material had been sold, in Kāšān and other Persian cities. Cakes of cobalt material were sold to craftsmen at prices ranging from 0.5 to 1 toman for a *man-e šāhī* (a unit of weight equivalent to slightly less than 6 kg; Żarrābī, p. 226).

Schlimmer also described the manufacture of "azure" glaze at Isfahan, where it was used for the repair of old glazed tiles in mosques and other public buildings. A few years later the British geographer A. Houtum Schindler provided much greater detail both on the mining and processing of the ore and on the preparation of ceramic glazes (Allan, pp. 116-17).

Cobalt was also mined elsewhere in Persia in the 19th century: at Qom (Wulff, *Crafts*, p. 147) and in the area of Anārak, southeast of Kāšān (Curzon, *Persian Question* II, p. 519; cf. Dayton, p. 63; Wulff, *Crafts*, pp. 147, 163; Mahrad, p. 341). In the 1930s cobalt ores were still being mined near Kāšān and Qom (Wulff, *Crafts*, p. 163), but by 1352 Š./1973 the blue powder containing cobalt for potters that was available in the *bāzār*s of Kāšān was being imported from Germany (Dayton, p. 390).

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