7 Photo catalogue

7.1 Introduction

In order to facilitate the species identification by means of the developed histological method a photo catalogue is provided. This includes photomicrographs of all the observed bone structure types, according to the classification system used in this thesis (see Chapter 2). Also the bone characteristics added to the classification system are shown. In addition some special features in diaphyseal bone structure are included to further enhance qualitative assessment of diaphyseal bone structure. The bone structure type abbreviations are mentioned in each figure. The asterisk indicates that the bone structure type was observed in a growth layer (Chapter 2).

The photo catalogue is divided into four sections, following the classification system given in Chapter 2. All the photomicrographs are orientated with the periosteal (external) surface up. They were taken by the author on a Leitz Dialux microscope with differential interference contrast (Nomarski) and polarisation. To enhance the visibility of the various bone structures and characteristics, different degrees of polarisation were used. Also different scales were used, which is shown in each photomicrograph.

Section 1  Primary bone structure: lamellar bone structure types
Figures 35a and 35b  lamellar non-vascular bone
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Figures 38a, 38b, 39a and 39b  lamellar bone with longitudinal primary osteons

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7.2 The catalogue

7.2.1 Primary bone structure: lamellar bone structure types

Figure 35a Transversal section of a human femur showing primary lamellar non-vascular bone structure (1a). Between the secondary osteons the primary bone structure consists of successive thin layers, the lamellae, without canals. L: lamellar bone structure; arrows indicate secondary osteons.

Figure 35b Transversal section of a cattle metatarsus showing primary lamellar non-vascular bone. A growth layer just below the periosteal (external) surface contains primary bone structure consisting of successive thin layers, lamellae, without canals (1a*). Underneath the growth layer a part of the general primary fibro-lamellar complex bone structure can be seen. L: lamellar bone structure; Flc: fibro-lamellar complex bone.
Figure 36 Transversal section of an ovicaprine (sheep or goat) femur showing primary lamellar bone structure with reticular vascular canals. A growth layer at the periosteal (external) surface contains lamellar bone with canals, not surrounded by concentric lamellae, that are oblique in orientation (1c3°). Below the growth layer a part of the general primary bone structure, plexiform fibro-lamellar complex bone, can be seen. L: lamellar bone structure; Plex: plexiform bone structure; arrow indicates reticular vascular canal.

Figure 37 Transversal section of an ovicaprine (sheep or goat) femur showing primary lamellar bone structure with radial vascular canals. A growth layer at the periosteal (external) surface contains lamellar bone with canals, not surrounded by concentric lamellae, that are radially orientated (1c4°). Below the growth layer a part of the general primary bone structure, plexiform fibro-lamellar complex bone, can be seen. L: lamellar bone structure; Plex: plexiform bone structure; arrow indicates radial vascular canal.
Figure 38a  Transversal section of a human femur showing primary lamellar bone structure with longitudinal primary osteons (1c1). Primary osteons are canals surrounded by concentric lamellae, but without a reversal line. As such, they blend into the primary lamellar bone. L: lamellar bone structure; arrows indicate primary osteons.

Figure 38b  Transversal section of a cattle radius showing primary lamellar bone structure with longitudinal primary osteons. A growth layer, containing lamellar bone with primary osteons, is situated within the general primary bone structure of plexiform fibro-lamellar complex bone (1c1*). L: lamellar bone structure; Plex: plexiform bone structure; arrow indicates primary osteon.
Figure 39a  Transversal section of a human femur showing primary lamellar bone structure with two circular rows of longitudinal primary osteons (1c5). Primary osteons are aligned and form rows within the lamellar bone. L: lamellar bone structure; arrows indicate rows of primary osteons.

Figure 39b  Transversal section of a cattle radius showing primary lamellar bone structure with a circular row of longitudinal primary osteons. A growth layer situated within the general primary bone structure of fibro-lamellar complex bone contains lamellar bone with primary osteons aligned (1c5*). L: lamellar bone structure; Flc: fibro-lamellar complex bone structure; arrow indicates row of primary osteons.
7.2.2  *Primary bone structure: fibrous bone structure types*

Figure 40  Transversal section of a human child femur showing primary fibrous non-vascular bone structure (1d). In the upper part of the thin section, an area of fibrous bone without vascular canals is located. Also fibrous bone with longitudinal primary osteons can be seen. F: fibrous non-vascular bone structure; arrows indicate primary osteons.

Figure 41  Transversal section of a horse metacarpus showing primary fibrous bone structure with two reticular vascular canals (1e3). These canals with an oblique orientation are not surrounded by concentric lamellae, in contrast to the longitudinal primary osteons from which they originate. In addition the canals are enlarged (this characteristic is explained in Fig. 58). F: fibrous bone structure; arrows indicate reticular vascular canals.
Figure 42  Transversal section of a horse femur showing primary fibrous bone structure with two radial vascular canals (1e4). These canals with a radial orientation are not surrounded by concentric lamellae, in contrast to the longitudinal primary osteons from which they originate. In addition the canals are enlarged (this characteristic is explained in Fig. 58). F: fibrous bone structure; arrows indicate radial vascular canals.

Figure 43a  Transversal section of a human child femur showing primary laminar fibro-lamellar complex bone structure (1f1). Longitudinal primary osteons form circular layers of lamellar bone. Above and below these circular layers of lamellar bone, sheets of fibrous bone can be seen. L: lamellar bone structure; F: fibrous bone structure; arrows indicate primary osteons).
Figure 43b Transversal section of a catte femur showing laminar fibro-lamellar complex primary bone structure (1f1). Longitudinal primary osteons are connected through circular primary osteons. In contrast to plexiform bone (see also Fig. 44), the longitudinal primary osteons are not connected through radial canals. Arrows indicate longitudinal primary osteons.

Figure 44 Transversal section of a pig tibia showing plexiform fibro-lamellar complex primary bone structure (1f2). Lamellar and fibrous layers are superimposed. The lamellar layers of primary osteons are united by radially orientated canals forming a three-dimensional meshwork or wire-netting. L: lamellar bone structure; F: fibrous bone structure; arrow indicates a radially orientated canal.
Figure 45a  Transversal section of a human child humerus showing reticular fibro-lamellar complex primary bone structure (1f3). A primary osteon situated within fibrous bone has an oblique orientation. This constitutes a simple form of reticular fibro-lamellar complex bone. F: fibrous bone; arrow indicates oblique primary osteon.

Figure 45b  Transversal section of a cattle femur showing reticular fibro-lamellar complex primary bone structure (1f3). Numerous primary osteons have an oblique orientation and are irregular anastomosed. Arrows indicate primary osteon with an oblique orientation.
Figure 46  Transversal section of a cattle metacarpus showing radial fibro-lamellar complex primary bone structure (1f4). The primary osteons in fibrous bone are radially orientated. Arrows indicate radially orientated primary osteons.

Figure 47  Transversal section of an oxen metacarpus showing radial fibro-lamellar complex primary bone structure with radial rows of longitudinal primary osteons (1f6). Between the radial orientated primary osteons radial rows of longitudinal primary osteons are present. Arrows indicate longitudinal primary osteons aligned in radial rows.
Figure 48a Transversal section of a cattle radius showing laminar/plexiform (in this case plexiform) fibro-lamellar complex primary bone structure with rows of longitudinal primary osteons (1f5a). Within a lamina, defined as the area of bone between two hypercalcified lines, rows of primary longitudinal osteons are located. Arrows indicate rows of primary osteons.

Figure 48b Transversal section of a horse humerus showing laminar/plexiform (in this case laminar) fibro-lamellar complex primary bone structure with a band of longitudinal primary osteons (1f5b). Instead of forming rows, the primary longitudinal osteons found between sheets of alternating lamellar and fibrous bone structure, are located in a band. Arrows indicate band of primary osteons.
Figure 49a  Transversal section of a human child tibia showing fibrous primary bone structure with longitudinal primary osteons (1f7). F: fibrous primary bone structure; arrows indicate primary osteons.

Figure 49b  Transversal section of a horse metacarpus showing fibrous primary bone structure with longitudinal primary osteons (1f7). F: fibrous primary bone structure; arrows indicate primary osteons.
Figure 49c  Transversal section of a human femur showing fibrous primary bone structure with longitudinal primary osteons. A growth layer consisting of fibrous bone with primary osteons (1f7*) is located within the general, primary lamellar bone structure. L: lamellar bone structure; F: fibrous bone structure; arrows indicate primary osteons.

Figure 50  Transversal section of a horse femur showing fibrous primary bone structure with circular rows of longitudinal primary osteons (1f8). Longitudinal primary osteons are aligned within fibrous bone. F: fibrous primary bone structure; arrow indicates row of primary osteons.
Figure 51a  Transversal section of a horse femur showing pseudo-laminar fibro-lamellar complex primary bone structure (1f1/1a-c). Layers of laminar fibro-lamellar complex bone, consisting of a fibrous and a lamellar component, and lamellar primary bone types are alternating. L: lamellar bone; F: fibrous bone.

Figure 51b  Transversal section of an ovicaprine (sheep or goat) femur showing pseudo-fibro-lamellar complex primary bone structure (1f/1a-c). Layers of fibro-lamellar complex bone, consisting of a fibrous and a lamellar component, and lamellar bone types are alternating. The fibro-lamellar bone can be laminar, plexiform, reticular, radial and laminar/plexiform with primary osteons in a row or band. L: lamellar bone; F: fibrous bone; arrow indicates reticular fibro-lamellar complex bone.
7.2.3 Secondary bone structure

Figure 52a Transversal section of a human femur showing lamellar primary bone structure with scattered secondary osteons (2a1a). Secondary osteons or Haversian systems consist of a central (Haversian) canal surrounded by concentric lamellae. They are set apart from the primary lamellar bone structure by a reversal line. L: lamellar bone structure; arrows indicate scattered secondary osteons.

Figure 52b Transversal section of a cattle radius showing plexiform fibro-lamellar complex primary bone structure with scattered osteons (2a1a). Secondary osteons or Haversian systems consist of a central (Haversian) canal surrounded by concentric lamellae. They are set apart from the primary plexiform fibro-lamellar bone structure by a reversal line, forming the boundary between the concentric lamellae of the osteon and the primary bone structure. Plex: plexiform primary bone structure; arrows indicate scattered secondary osteons.
Figure 53a Transversal section of a human femur showing lamellar primary bone structure with a row of scattered secondary osteons (2a1b). Three secondary osteons are aligned at the periosteal (external) surface. L: lamellar primary bone structure; arrow indicates scattered secondary osteons with organisation.

Figure 53b Transversal section of a cattle metatarsus showing plexiform fibro-lamellar primary bone structure with a row of scattered secondary osteons (2a1b). Four secondary osteons are aligned within plexiform primary bone. Plex: plexiform primary bone structure; arrow indicating scattered secondary osteons with organisation.
Figure 54a Transversal section of a human femur showing dense secondary osteons (2a2a) with longitudinal Haversian canals (HC1). The Haversian systems consist only of a central longitudinal canal. HC1: longitudinal Haversian canal; arrows indicate secondary osteons.

Figure 54b Transversal section of a cattle metatarsus showing dense secondary osteons (2a2a) with a reticular canal (HC3) and longitudinal Haversian canals (HC1). In general, the densely packed Haversian systems have only a central, longitudinal canal, but also oblique canals coming out of one of the Haversian systems are present. HC1: longitudinal Haversian canal; HC3: reticular Haversian canal; arrows indicate secondary osteons.
Figure 55a  Transversal section of a horse metacarpus showing organisation of dense secondary osteon structure (2a2b). Densely packed secondary osteons are aligned in rows. Arrows indicate rows of secondary osteons.

Figure 55b  Transversal section of a horse metacarpus showing organisation of dense secondary osteon structure (2a2b). Detail of the rows of secondary osteons. Arrows indicate rows of secondary osteons.
7.2.4 Added characteristics and special features

Figure 56a Transversal section of a goat tibia showing a growth layer of lamellar non-vascular primary bone structure (1a*) in a plexiform fibro-lamellar complex primary bone structure (1f2). Within the general primary bone structure of plexiform fibro-lamellar complex bone a distinct layer consisting of lamellar primary bone can be seen. L: lamellar bone structure; Plex: plexiform bone structure; arrows indicate growth layer.

Figure 56b Transversal section of a cattle metatarsus showing a growth layer of lamellar non vascular primary bone (1a*) in plexiform fibro-lamellar complex primary bone structure (1f2). Detail of a distinct layer of lamellar primary bone within the general, fibro-lamellar bone structure. L: lamellar bone structure; Flc: fibro-lamellar bone; arrows indicate growth layer.
Figure 57 Transversal section of a human child femur showing lines of arrested growth. These growth marks near the periosteal (external) surface indicate several temporary arrests of growth, after which bone growth, lamellar, continues. Arrows indicate lines of arrested growth.

Figure 58 Transversal section of a horse radius showing porosity. This bone structure shows an enlargement of the primary vascular canals and primary osteons in fibro-lamellar complex bone. Note that it is not a remodelling feature, in which primary bone is resorbed by osteoclasts and secondary osteons are formed. Arrows indicate enlarged canals.
Figure 59a Transversal section of a human child femur showing the composition of fibro-lamellar complex bone structure: the lamellar component is predominant. Within a lamina, defined as the area between two hypercalcified lines, lamellar bone takes up more than half of the area. L: lamellar component; F: fibrous component; arrows indicate hypercalcified lines.

Figure 59b Transversal section of a horse humerus showing the composition of fibro-lamellar complex bone structure: the lamellar component is predominant. Within a lamina, defined as the area between two hypercalcified lines, lamellar bone takes up more than half of the area. L: lamellar component; F: fibrous component; arrows indicate hypercalcified lines.
Figure 59c  Transversal section of a pig radius showing the composition of fibro-lamellar complex bone structure: the fibrous component is predominant. Within a lamina, defined as the area between two hypercalcified lines, fibrous bone takes up more than half of the area. F: fibrous component; L: lamellar component; arrows indicate hypercalcified lines.

Figure 59d  Transversal section of a cattle femur showing the composition of fibro-lamellar complex bone structure: the fibrous and lamellar component are equal in thickness. Within a lamina, defined as the area between two hypercalcified lines, the fibrous and lamella bone each take up half of the area. F: fibrous component; L: lamellar component; arrows indicate hypercalcified lines.
Figure 60a  Transversal section of a human femur showing longitudinal Haversian canals (HC1) with a connecting Volkmann’s canal (arrow). The central canals of two secondary osteons are connected through a Volkmann’s canal. HC1: longitudinal Haversian canal; arrow indicates Volkmann’s canal.

Figure 60b  Transversal section of a cattle femur showing a reticular Haversian canal (HC3). Canals with an oblique orientation, come out of the central longitudinal canal of a secondary osteon. Arrows indicate the reticular canals.
Figure 61a  Transversal section of a human child femur showing development of the bone structure. At the periosteal (external) surface incomplete fibro-lamellar bone structure can be seen.

Figure 61b  Transversal section of a horse metacarpus showing development of the bone structure. At the periosteal (external) surface incomplete fibro-lamellar bone structure can be seen.
Figure 62a  Transversal section of an oxen metacarpus showing metaphyseal bone structure. The bone structure in the endosteal area shows a different arrangement than diaphyseal bone; an irregular convoluted pattern. Arrow indicates the convoluted bone in the endosteal area.

Figure 62b  Transversal section of a pig radius showing metaphyseal bone. The bone structure in the endosteal area is differently arranged than diaphyseal bone, consisting of convoluted bone with several canals. Arrow indicates convoluted bone.