Chapter 1
Introduction and History of Research in the Senèze Maar

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Abstract The Senèze paleontological site (Haute-Loire, France) is situated on the banks of a maar lake, in the Auvergne volcanic region. It was first reported by M. Boule in 1892, following the chance discovery of a proboscidean skeleton reported by local scholars. Pierre Philis, a local peasant, became interested in fossil mammals and collected them in the fields around the hamlet over more than 40 years, from the end of the nineteenth century until the start of World War II. He sold them to museum curators, especially to H. G. Stehlin (Naturhistorisches Musem Basel), C. Depéret (Faculté des Sciences de Lyon), C. Gaillard (Muséum d'Histoire naturelle de Lyon) and M. Boule (Muséum national d'Histoire naturelle, Paris). The resulting collections, including mounted skeletons exhibited in museums, made the site famous. New species (and genera) of ruminant artiodactyls, primate and carnivores were defined from Senèze, which became a biochronological reference site for the late Villafranchian. After the war, only a few short field campaigns (prospecting, survey, mapping and minimal excavation) were undertaken, and it became clear that renewed research was required to better understand this important site. The Franco-American fieldwork led by the authors began with a survey and request for excavation permits in 2000, followed by intensive mapping, prospection and excavation from 2001–2006. After a brief review of previous work at and about Senèze, each year of our research is summarized and illustrated. The succeeding chapters of this volume are also "previewed".

Résumé Le gisement paléontologique de Senèze (Haute-Loire, France) se situe sur le pourtour d'un ancien lac formé dans un maar, dans la région volcanique de l'Auvergne. Il a été signalé pour la première fois par M. Boule en 1892, à la suite de la découverte fortuite d'un squelette de proboscidien associé à d'autres restes de mammifères fossiles, signalés par des érudits locaux. Un paysan du hameau, Pierre Philis, s'est intéressé à ces ossements fossiles. Le gisement étant très riche, il en a récolté pendant une quarantaine d'années, de la fin du XIX^{e} siècle jusqu'au début de la Deuxième Guerre mondiale. Il les a proposé aux conservateurs de musées et en a ainsi vendu une grande quantité à H. G. Stehlin (Naturhistorisches Museum Basel), C. Depéret (Faculté des Sciences de Lyon), C. Gaillard (Muséum d'Histoire naturelle de Lyon) et M. Boule (Muséum national d'Histoire naturelle, Paris). Ces collections, et entre autres les squelettes montés exposés dans les musées, ont fait la notoriété du site. Ces restes fossiles ont permis de définir de nouvelles espèces (et genres) ruminants, de primate et de carnivores. Senèze est devenu une référence biostratigraphique pour le Villafranchien supérieur. Après guerre, le gisement n'a fait l'objet que de courtes explorations de terrain (prospections, sondage géologique, prélèvements et fouille ponctuelle). Ce site majeur pour l'étude des faunes du Plio-Pléistocène

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nécessitait une reprise des recherches. En 2000 nous avons fait un sondage et obtenu une autorisation de fouille programmée qui a été renouvelée jusqu'en 2006. Dans cette introduction, après un historique et un survol des recherches antérieures, nous exposons nos propres travaux de prospection et de fouille. Les chapitres de ce volume sont ensuite présentés.

Keywords Fieldwork • Pierre Philis • Villafranchian

Mots-clés Fouilles programmées • Pierre Philis • Villafranchien

Work at Senèze in the Nineteenth and Twentieth Centuries

The Discovery of Senèze Mammals in the Late 19th Century

In the early 1890s, the remains of fossil mammals were discovered by chance in a farm field in the hamlet of Senèze, in the commune of Domeyrat (Haute-Loire Department, central France). Three antiquarian scholars of the region, H. Mosnier, A. Vernière and P. le Blanc, advised Marcellin Boule of the Muséum national d'Histoire naturelle in Paris (MNHN) of this find. Boule had worked on the geology and fossil mammals of the region (Boule 1892–1893), and he went to Senèze, accompanied by Albert Gaudry (the Professor of Paleontology at the MNHN). They excavated an almost complete skeleton identified as *Elephas* (now *Mammuthus*) *meridionalis*, associated with remains of (sic) *Equus stenonis*, *Bos elatus*, *Rhinoceros*, *Hyaena* and antlers of several cervids, buried in volcanic ash layers exposed by "storm rains" (Boule 1892).

A few years earlier, the MNHN had been deeply involved in the excavation and reconstruction of a mammoth (*M. meridionalis*) skeleton from Durfort (Gard Department, southeastern France). They also had to deal with the problems and costs of transporting, mounting and installing the skeleton for exhibit at MNHN (Gaudry 1893), at a cost estimated around 30,000 francs (Lascombe 1894). Gaudry was not prepared to initiate a similarly complicated and expensive project for the Senèze skeleton, which was even larger. Thus, the Senèze proboscidean skeleton was left in place, and only its molars and some rhino and cervid bones were transported to Paris and catalogued as MNHN-P 849, 1892-15. Gaudry (1896, p. 189, Fig. 190) published the drawing of one lower molar, and two teeth were exhibited in the new Galerie de Paléontologie, opened in 1898 (Gaudry 1898), where they remain (Fig. 1.1). The specimen was compared to other finds of this species and said to be similar to that from the British Crags, older than those from Durfort or the Cromer Forest Bed of Britain (Boule 1892; Gaudry 1896). In turn, Senèze was thought to be younger than the nearby volcanic sites of Chilhac or Le Coupet, which had yielded mastodons. These three sites were considered paleontological Pompeiis, preserving the fauna contemporaneous with their eruptions (Boule 1892, p. 626; Gaudry 1898, p. 822). The remainder of the Senèze proboscidean skeleton was left in place, from where Boule hoped it would be included in local collections, but in fact it deteriorated badly and was eventually salvaged in part by a team from Lyon: Depéret and Mayet (1912) roundly criticized this abandonment of the fossil, which led to its deterioration.

The discovery of the mammoth must have been an extraordinary event for the peasant inhabitants of the tiny Senèze hamlet. A local farmboy, then 12 years old, witnessed the extraction of the gigantic bones and became interested in vertebrate paleontology. That boy, Pierre Philis, was a central figure in the recovery (and sale) of fossils from Senèze over the next half century (1892–1942; Faure et al. 2022). Several years later, Philis discovered a partial skull of "*Rhinoceros etruscus*" and sold it to the local collector Vernière (Schaub 1943b). Vernière had kept in contact with Boule and offered him the specimen, which they donated to the MNHN (catalogued as MNHN-P 942, 1896-22; Faure et al. 2022: 342; Fig. 1.2). For the second time, a Senèze fossil entered the MNHN collection.

Fig. 1.1 Two upper molars of *Mammuthus meridionalis* MNHN-F 849, 1892-15 on exhibit in the Paleontology Hall of the Muséum national d'Histoire naturelle, Paris, part of the first fossil mammal collected at Senèze, in 1892 (© Sevket Sen, MNHN)

The Philis Era

Philis Starts to Contact Buyers. By 1906, Philis apparently began to search actively for fossils on his farmland, in whatever time he could spare from agriculture. Beginning in 1907, Philis corresponded with Hans Georg Stehlin (Curator of Osteology [i.e., Paleontology] at the Naturhistorisches Museum Basel [NMB]). Based on letters they exchanged in June 1907, Stehlin visited Senèze in late 1906 or early 1907 regarding an order for Senèze fossils. The first major discovery made by Philis was a complete skeleton of "*Machairodus*" (today *Megantereon cultridens*), found in 1909 and reported widely in the national press (Faure et al. 2022). This specimen was acquired by the NMB, where it is on exhibit today, following a new restoration in 2013.

Philis soon widened his circle of clients within France. In 1908, S. Rougier of the neighboring commune of La Chomette helped Philis contact Boule, who had succeeded Gaudry at MNHN in 1902 and was known for his work on the geology of the Velay area. Boule continued to be interested in Senèze fossils into the 1920s, and in August,

Fig. 1.2 Left, portrait of Pierre Philis, date unknown (after 1927; © Philis archives). Right, cranium of "*Rhinoceros etruscus*" from Senèze MNHN-F 1896-22, on exhibit in the Paleontology Hall of the Muséum national d'Histoire naturelle, Paris (© Sevket Sen, MNHN). This was the first fossil collected by Pierre Philis, then just 16 years old. It was sold to Antoine Vernière; he and M. Boule gave it to the MNHN collection in 1896

1921, he sent Pierre Teilhard de Chardin, who was staying at a Jesuit residence near Le Puy, to see P. Philis. Teilhard termed Philis a true "fossils hunter" in a letter to Boule (Faure et al. 2022: 333–334).

Depéret, Gaillard and the Senèze Collections in Lyon. The third of Philis' main customers was Charles Depéret, Professor of Geology in the Faculty of Sciences at Lyon (FSL; Fig. 1.3). He became interested in Senèze by 1908, when he sent his paleontological preparator, Laurent Maurette, to work there with Philis and train the young farmer how to prepare fossils and introduce him to the techniques of excavating fossil vertebrates (Faure et al. 2022: 335). With paleontologist Lucien Mayet (who taught the course on anthropology and human paleontology at FSL), Depéret described the results of the first intensive prospection and excavation at Senèze, mainly on the farmland of MM. Philis and Thomas (Depéret and Mayet 1911, 1912). In a short preliminary report, Depéret and Mayet (1911, p. 262) wrote that "le gisement de Senèze contient des squelettes complets, avec tous les os restés en connexion, condition des plus rares dans les gisements européens et qui ne se rencontrent guère que dans les magnifiques gisements de l'ouest des États-Unis." ("Senèze yielded complete skeletons, with all the bones in connection, which was rare in European localities and hardly occurred except in the magnificent localities of the American West"; our translation, also below). They also noted that a "savant étranger" (foreign scholar), Dr. Stehlin of Basel, who zealously followed discoveries of fossils in French localities, had obtained a quite important collection of Senèze fossils for the NMB. In light of an awareness to protect fossils from French deposits from being removed, they suggested that it was necessary for a French scientific institution to take over excavations at Senèze; they reported that it had become possible for the Faculté des Sciences Lyon (in part thanks to the support of the Association française pour l'avancement des Sciences) to begin careful exploration of the site. Depéret and Mayet (1912) reported

Fig. 1.3 Portrait of Charles Depéret in university regalia. Published in Multiple Authors (1929)

the results of their first year of intensive research at Senèze, including discussion of the regional geology and recognition of the volcanic origin of the depression around the hamlet. They did not use the term "maar", but it seems that they understood the concept of a volcanic lake. They discussed the local stratigraphy in several agricultural fields (giving the names of the landowners) and presented a preliminary sketch of a section based on natural exposures in a ravine where Philis had collected extensively, on the slopes above the volcanic valley. They also discussed each of the fossil species recovered, including one new cervid ("*Cervus senezensis*"), offering their thoughts about the possibility of eventually recovering evidence of early human occupation. A few years later, Depéret et al. (1923) wrote a major review of Pliocene elephantids, including the material from Senèze (see Ménouret and Guérin 2024). Meanwhile, C. Gaillard began to build a Senèze collection at the Muséum d'Histoire naturelle de Lyon.

Depéret's third and last paper about Senèze fossils was the description of *Dolichopithecus arvernensis* in 1929. As Faure et al. (2022: 358) pointed out, he had long hoped for remains of Pliocene humans, with primate fossils a close second option. In February 1924, Philis informed Depéret that he had found a small skull which he thought might be of a monkey. At Depéret's request, Philis sent the specimen to Lyon, where Depéret determined that it was indeed a cercopithecid monkey that he considered was a representative of *Dolichopithecus*, a genus which he had described from the early Pliocene of Perpignan in 1889. Depéret reported this find, under the new name of *Dolichopithecus arvernensis*, at the 16th International Geological Congress (Madrid, May 1926) and then named and described it briefly in the publication of his talk, a review of French Pliocene primates (Depéret 1928). A more detailed description and comparison was published a year later (Depéret 1929), just months before his death. The species was later transferred to the genus *Paradolichopithecus* Necrasov et al., 1961 (see Delson 2024). There was great interest in the find in the 1920s and 1930s, both among scientists and collectors: Claudius Côte, an antiquarian and major benefactor of the Lyon Muséum d'Histoire naturelle (MHNL), asked Philis numerous times to find him another such "beau crâne de singe" (Faure et al. 2022: Fig. 8).

Frédéric Roman, assistant professor in the FSL, succeeded Depéret as Professor after the latter's death in 1929. Jacques Dareste de la Chavanne had succeeded Maurette after his death in 1917. Together (Roman and Dareste de la Chavanne 1931) they announced the discovery of a Senèze elk skeleton identified as *Alces latifrons* Johnson, 1874. Azzaroli (1952) later determined that it typified the new genus and species *Libralces* (today *Cervalces*) *gallicus* (see Valli 2024).

In the early decades of the twentieth century, museums and university paleontology labs desired to acquire complete skeletons of fossils in order to mount them for exhibit purposes. Seven skeletons were obtained by the FSL (Gómez Llueca 1921; Roman 1931, Fig. 2, 1935), catalogued at the time as: *Cervus senezensis* (Roman 1935: Fig. 17), *Cervus*

philisi, Alces latifrons, Leptobos etruscus, Rhinoceros etruscus, Machairodus crenatidens (Gómez Llueca 1929: Fig. 3; Ballesio 1963: pl. 4; Van Hooijdonk 2006: Fig. 9) and *Equus stenonis*. Up to the time of the move from the historic university building in central Lyon to the new campus of La Doua in Villeurbanne (at the time of the creation of the Université Claude Bernard-Lyon 1 or UCB-Lyon 1), these skeletons were among the flagship attractions of the paleontological collection (David 1962, p. 74). At the same time, the NMB had eight mounted skeletons of Senèze fossils excavated by Philis. Six of these are still on public exhibit in the permanent collection: *Megantereon cultridens* (Schaub 1925; Van Hooijdonk 2006: Fig. 12), *Stephanorhinus etruscus* (Schaub 1943b, Fig. 1; Wittmann 1980, Fig. 79; Van Hooijdonk 2006, Fig. 5), *Allohippus senezensis* (Schaub 1943b, Fig. 2), *Sus strozzii* (Schaub 1943b, Fig. 3), *Gallogoral meneghinii* (Schaub 1922, Fig. 2; Van Hooijdonk 2006: Fig. 4) and *Metacervoceros rhenanus philisi* (Schaub 1941, Fig. 1). Two others (*Gallogoral meneghinii* and *Eucladoceros ctenoides senezensis*) are kept in storage off limits to the public.

In 1920, W. D. Matthew of the American Museum of Natural History (AMNH) traveled through Europe to see the state of museums after World War I. In Basel, he saw "a Pliocene collection from Senèze that equals the Val d'Arno fauna or the Asti fauna in richness. Proboscideans are scarce, but all the smaller forms far better represented. Dr. Stehlin has already several fine skeletons mounted from this horizon–*Cervus*, *Machaerodus*, etc. Among the antelopes is one quite near to *Oreamnus* (our mountain goat). This is certainly one of the great faunas, and it is fine to see it in such competent hands". In Lyon he was impressed by various FSL collections, including their material from Senèze, writing that it is "a very splendid collection and I wish I could spend a couple of months studying it" (Matthew 1921: 189–190). Matthew was the first AMNH paleontologist to develop an interest in the fossil mammals of Senèze; it would take eighty years for a second (Delson) to realize the wish of his predecessor.

Stehlin, Helbing and Schaub—Building the Senèze Collection in Basel. Hans Georg Stehlin of the NMB continued to purchase fossils from Philis, but he only wrote one major paper about them, summarizing the Senèze fauna in 1923. He was joined after 1910 by Hermann Helbing and Samuel Schaub (Fig. 1.4; Faure et al. 2022: 339). Helbing worked at Senèze with Philis on several occasions. Schaub started as a volunteer at NMB in 1913, joined the staff in 1922 and succeeded Stehlin (who died in 1941) in 1943. Schaub worked on Senèze fossils sold by Philis starting in 1913 and first visited the site in 1920, after which he collaborated with Philis until the latter's death in 1942. He wrote numerous articles about this material, often in comparison with specimens from other Pliocene sites: among bovids (see Crégut-Bonnoure 2024), Schaub (1922) described and named *Nemorhoedus philisi* (a misspelling of *Nemorhaedus*, now *Gallogoral meneghinii*); he (Schaub 1923) also described and named *Procamptoceras brivatense* and *Megalovis latifrons*, as well as discussed *Tragelaphus* (now *Gazellospira*) *torticornis*, *Deperetia ardea* (now *Pliotragus ardeus*) and "*Antilope* sp." (now included in *Megalovis latifrons*). Among carnivorans (see Argant 2024), Schaub (1925) described a partial skeleton of *Machaerodus* (now *Megantereon*) *cultridens*; later, he (Schaub 1942) named *Brachyprosopus vireti* for some fragments which are now included in *Acinonyx pardinensis*. Finally, he (Schaub 1941) named *Cervus philisi*, now considered a subspecies of *Metacervoceros rhenanus* (see Valli 2024).

Schaub was among the first paleontologists to utilize screen-washing of sediment in the laboratory to enable searching for micromammal fossils. Screen-washing of material from Senèze led to the recovery of several small teeth. Stehlin (1923) included in his faunal list *Lepus*, *Sciurus*, and two species each of *Mimomys* and *Arvicola*. A few years later, he allowed the Hungarian paleontologist T. Kormos to review the arvicolids from Senèze, and Kormos (1931) identified three species of *Mimomys*. Maul (2004) re-evaluated the few teeth known and broadly agreed with Kormos, recognizing the *Mimomys pliocaenicus/M. ostramosensis* group and the *M. pitymyoides* group.

Schaub (1943) presented a major survey of the Senèze assemblage based on the Basel material. In addition to taxa recognized previously, he noted the presence of a sciurid close to the Asian *Eutamias* and the leporid *Oryctolagus* cf. *lacosti*; these taxa have not been re-examined recently.

Also in 1943 (but apparently unaware of Schaub's review), Masson (1943) submitted a Diplôme d'Etudes Supérieures on Senèze at the FSL. He reviewed the geology of the site and its fauna, with a special section on ruminant artiodactyls. In addition to birds and mammals, his faunal list included a turtle, a frog and molluscs of the genera *Limnea* and *Ancylus*.

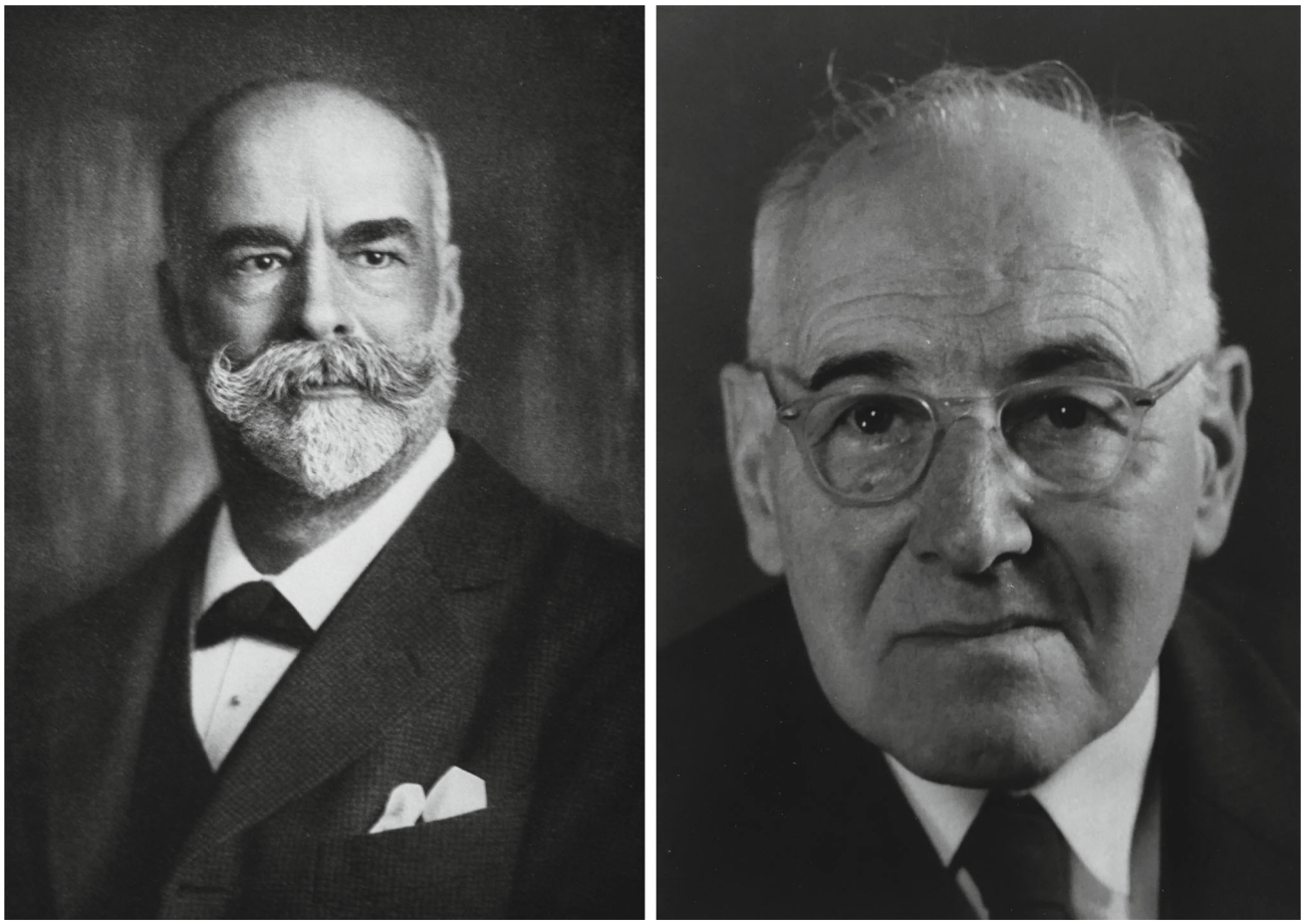

Fig. 1.4 Portraits of (left to right): Hans Georg Stehlin, Samuel Schaub (© NMB archives)

Senèze After Philis and World War II

Fieldwork. After the war, the conduct of archaeology in France changed significantly. In 1941 a law required all people wishing to carry out excavations in sites which may have a relationship to prehistory to first have an excavation authorization. This law was validated in 1945. All Plio-Pleistocene deposits were affected by this law, which put an end to excavations without state control. This limited the possibility for amateurs like Philis to undertake the type of work that he did before the war (Faure et al. 2022: 364–368). Only a limited number of short field campaigns were undertaken at Senèze, while individual studies focused on specific taxa or included Senèze fossils in broader analyses.

In 1953, J. Roger and colleagues from the MNHN undertook several days' fieldwork at Senèze (Roger 1954; also Brébion et al. 1953). They examined the local geology and observed the presence of associated mammalian skeletons in one or two locations, while in others the elements were dissociated. It is unclear if they collected any fossils, but Roger (1954) noted that some property to the north of the "Philis ravine" had been purchased by the MNHN for that purpose. A map showed contour lines and the location of a number of fossiliferous points and observed sections, but without much detail. Roger (1954) also suggested that the faunal list included species which were adapted to widely different environments (forest, woodland, steppe) and proposed that a taphonomic study would be useful.

Bout (from 1960 onward) discussed the geology and stratigraphy of numerous French Villafranchian localities. In 1970, he described the geological setting of the Senèze maar and the sequence of events which formed it (Bout 1970b). As seen in his Fig. 1.1, he mapped the site as a large scoria cone to the (north)west of a deep infilled maar, about 500 m across. The scoria cone was formed first, at the source of a lava flow that covered the area of the site. Next, the maar formed in the crater of an explosive vent that penetrated the flow and left a deposit of explosion breccia against the western side of the scoria cone. As explosive activity died

down, the maar lake slowly filled in with lacustrine deposits. Finally, offwash slope deposits built up on the inner (especially western) slopes of the maar. Bout (1970a, 1970b; also Couthures 1989, following Depéret & Mayet 1912 and Roger 1954) indicated that the mammalian fauna was derived from the upper levels of the maar infilling as well as from the slope deposits.

Elhaï and Grangeon (1963) briefly studied the pollen from the upper 60 m of a 100 m core drilled into the maar in 1962 (Grangeon 1962). Elhaï (1969) presented a more detailed analysis of the upper 120 m of a 175 m core taken in 1965. Elhaï reported that the lowest 52 m of the core was composed of solidified tuff and crater debris; this was overlain by 43 m of fluvio-lacustrine sediments, in turn underlying 80 m of diatomaceous clay, with a sandy layer between 28–22 m below the top. Elhaï described a general alternation between two main plant assemblages: a warm-climate forest of thermophile, generally leafy trees, both local and exotic; and a cooler-climate forest of conifers mixed with herbs, the latter sometimes expanding to cover most of the ground surface. Elhaï divided the core into a series of phases dominated by one of these two assemblages: from 120–94 m, a temperate phase with poorly diversified vegetation might signify the first "recovery" after a significant cold interval (for Elhaï, perhaps the start of the Pleistocene); this was followed by a cool and humid phase from 94–76 m. Between 76–43 m came the interval richest in thermophile plants and poorest in herbs, within which the earlier part was humid and temperate, while the later part was humid and cool; between 43–29 m, a cold and relatively dry phase occurred; and from 24 m to the top of the core came a complex alternation of three cycles, each with a temperate-humid subphase followed by a cool or cold subphase.

In studying the diatoms from Elhaï's core, Ehrlich (1968) distinguished three main intervals: from 107–97 m, littoral species of diatoms were more common than planktonic ones; between 96–20 m, littoral, benthic and epiphytic taxa disappeared to be replaced by a euplanktonic species; and from 19 m up, the littoral forms again dominated. Bout (1970a, 1970b) interpreted these three phases to imply an early period of slow lake filling, with shore diatoms washed in; followed by a deep lake where plankton flourished; and finally an interval when the lake was filling with sediment and only shallow-water diatom species flourished. Ehrlich (1968) also estimated that the number of laminations in the diatomite (which she interpreted as annual) was probably between $2–3 \times 10^5$. Bout (1970a, 1970b) combined that with an early estimate of 1.9 Ma for the underlying lava to suggest that the upper levels of the maar might have dated to 1.6 Ma and the mammalian fauna perhaps to 1.5 Ma.

Pelletier (1968) studied the sedimentology and mineralogy of three samples of sand in different levels of the core (see Debard 2024). In a discussion of petrology of the volcanic deposits at Senèze, Devis (1970) again noted a decline in lake depth over time and pointed out two levels with feldspar crystals. The partial skeleton of a fish found in the core was reported by Gaudant (1975) as representing *Tinca* (the tench). Another coring program was undertaken in 1989, with several short cores taken near the earlier one (see below, Roger et al. 2000).

Prévot and Dalrymple (1970) reported paleomagnetic data for the upper 132.5 m of the 1965 core. The analyzed section was entirely reversed, except for a 5–10 m normal zone from 17.5 to somewhere between 23.5 and 28 m below the top of the core. Prévot and Dalrymple suggested that the normal might correlate to the "Lower Olduvai" which they thought dated ca. 2.1 Ma. They also reported a whole-rock K–Ar age of 2.3 ± 0.15 Ma for samples of the Pié de Charenty basanite lava flow, assumed to predate the Senèze maar deposits. Couthures and Pastre (1983) obtained a date of 2.52 ± 0.06 Ma for the same flow, equivalent within the error ranges [Couthures (1989) reported the date as 2.48 ± 0.06 Ma]. Both Prévot and Dalrymple and later Couthures and Pastre reported a reversed polarity for the flow, correlated to the lower Matuyama chron. Prévot and Dalrymple (1970) further suggested that the normal magnetozone was the Réunion "Event" (then called the "Lower Olduvai"), implying that the Senèze fauna dated ca. 2.1–2.0 Ma.

C. Guth (Université de Poitiers) worked briefly at Senèze in the early 1960s, seeking fossils in two locations as indicated on the cadastral plan published by Parenti et al. (2024, Fig. 2.2). Guth (1975) reported finding a partial juvenile rhinocerotid (*Dicerorhinus etruscus*) along with specimens of *Canis etruscus*, *Eucladoceros* sp., "*Cervus philisi*" (now *Metacervoceros rhenanus philisi*), and indeterminate equid and bovid; he also reported work at Chilhac and Blassac-la-Girondie, southwest of Senèze.

The last fieldwork before our campaigns was undertaken by J. Couthures, who proposed the hypothesis that the death assemblage from Senèze was the result of intermittent CO_2 emission over a long time, leading to asphyxiation of mammals from diverse habitats (Couthures 1989). In part to test that hypothesis, Couthures (with D. Ablin and D. Hadjouis) undertook a single excavation campaign in August, 1991 (Couthures et al. 1991). They cleaned a section in or near the "Philis ravine" and recognized nine geological layers. They recovered four fossils: a horn core of *Procamptoceros* (figured in Lacombat et al. 2010, p. 77), hindlimb bones of a cervid, a cervid foot bone and a tooth of *Equus stenonis*. No further publication resulted from this work.

Analyses. In terms of systematic paleontology of ungulates, Richard (1944) wrote a short note about milk teeth of *Equus stenonis* from Senèze. Prat (1964) reviewed Villafranchian equids and described *Equus stenonis senezensis* for the same material (see Eisenmann and Delson 2024). Azzaroli (1952) named *Libralces gallicus* for two specimens of elk described earlier (see above); later he (Azzaroli 1982) included the species in the genus *Cervalces*. Breda (2001) suggested that the postcranial elements associated by Azzaroli with the holotype cranium were from a different individual and instead associated the postcranium of Azzaroli's paratype with that cranium. Heintz (1970) revised the Villafranchian deer from Spain and France, and he recognized four taxa from Senèze, including the new subspecies currently termed *Croizetoceros ramosus minor*. Pfeiffer (1999, 2005) reviewed the place of *Dama* among fossil cervids and discussed the Senèze taxa among others (see Valli 2024). Faure and Guérin (1979) examined supposed hippopotamids from Senèze and determined that none were correctly identified, but this idea has continued to appear in publications (see Crégut et al. 2024). Guérin (1980) studied the Senèze rhinocerotid in his doctoral thesis and attributed it to *Dicerorhinus* (*Brandtorhinus*) *etruscus etruscus*. Fortelius et al. (1993) moved this species into *Stephanorhinus*, but Guérin (e.g., 2024) always disagreed with that view and retained the former taxonomy. Duvernois and Guérin (1989) discussed bovids from Senèze as part of a broader work, and Duvernois (in that article) named *Leptobos furtivus* for bovine specimens from the site (see Crégut-Bonnoure 2024).

Numerous scholars have worked on Senèze carnivores (see A. Argant 2024). Ballesio (1963) studied the sabertooth cat *Homotherium crenatidens* in the FSL collection, while Perrot et al. (1972) discussed the paleopathology of a humerus of that species. Turner (1987) reviewed Old World *Megantereon*, including that from Senèze, and Antón and Werdelin (1998) discussed the skull of that cat. Both felids from Senèze were studied by Van Hooijdonk (2006), while Christiansen and Adolfssen (2007) focused on the osteology and ecology of *Megantereon cultridens*. Martin (1973) named three new Villafranchian canids, including *Canis senezensis*, and Mazza and Rustioni (1994) discussed the *Ursus* from Senèze.

The Senèze fauna was considered to belong to a later part of the Villafranchian "stage" (now land mammal age), by numerous researchers in the 1960's and 1970's. Heintz (1970) defined four successive phases based on cervids from France and Spain, of which the third (Villafranchien supérieur A) was the "zone de Senèze". Azzaroli (1970) broadly followed this subdivision, but he was uncertain whether the Senèze assemblage belonged in the earlier or later part of the upper Villafranchian. Mein (1975) proposed a system of numbered MN "zones" which divided Neogene time based on associations of mammalian taxa. The early Villafranchian was equated to MN 16, the middle Villafranchian to MN 17 and the late Villafranchian formed part of a subsequent, unnumbered unit. Guérin (1980, 1982) added MNQ 18 and 19 for the late Villafranchian (as well as several later units). Mein (1989) included Senèze in MN 17, whereas Guérin (1982) retained that site as one of the reference faunas in MNQ 18. We follow the latter concept, as will be discussed in greater detail in Chap. 17 (Crégut-Bonnoure et al. 2024), which makes the geochronological and biochronological position of Senèze important in a pan-European context.

In the meantime, Heintz et al. (1974) provided a complete faunal list of larger mammals for many French Villafranchian sites including Senèze. Azzaroli et al. (1988) proposed that the Senèze local fauna was composed of two associations of different age, on the basis of an analysis of Schaub's (1943b) faunal list plus original studies; these authors, however, did not cite and may not have been aware of the revision by Heintz et al. (1974). Azzaroli et al. (1988, p. 82) suggested that the larger and more speciose assemblage, including (in current taxonomy) *Eucladoceros ctenoides senezensis*, *Metacervoceros rhenanus philisi*, *Croizetoceros ramosus minor*, *Nyctereutes* and *Paradolichopithecus*, would fit in the middle Villafranchian. To the contrary, they considered that *Cervalces gallicus*, *Equus bressanus*, "a small equid which may possibly be *Equus stehlini*" and perhaps *Megalovis* "clearly point to a late Villafranchian age." They suggested that the former group, presumably from the upper levels of the maar, might date to ca. 2 Ma, in their middle Villafranchian, while the less extensive faunule might date to ca. 1 Ma, near the end of the Villafranchian as they conceived of it. These and later assessments will also be discussed in Chap. 17 (Crégut-Bonnoure et al. 2024).

Senèze in the Twenty-First Century

The Franco-American Research Project Year by Year

2000. The origin of this project is discussed above in the Preface. As noted there, Faure received a permit allowing survey and paleontological prospecting from the *Ministère de la Culture et de la Communication*. A small exploratory team (Faure, Guérin, Delson, Evelyne Debard and Andrea Valli [then a UCB-Lyon 1 PhD student]) spent a week in June 2000 in the Senèze area (Fig. 1.5; located at 45.241 N, 3.483 E; see Fig. 2.1). We began by examining the cadastral plan of the hamlet of Senèze (part of the commune of Domeyrat). This plan shows the ownership of land plots (parcels) as inherited and often subdivided over time. Thanks to the indispensable help of Mme R. Martin of

Domeyrat, we were able to locate the plots of land and meet their current owners. Checking the plan against local geomorphology, altitude and ground cover, the team selected a number of parcels which might be likely sites for excavation and then spoke with their proprietors, mainly landowners who were desended from those mentioned by Depéret and Mayet (1912) as owning fossiliferous properties. Many of the holdings had been divided through inheritance, but several of the proprietors were willing to allow excavation on their land the following year (see below).

Fig. 1.5 C. Guérin, M. Faure and E. Delson at the entrance to the hamlet of Senèze

2001. With the authorization and support of the Mayor of Domeyrat and permission from the selected landowners, Faure received a survey and prospecting permit and funding from the *Ministère de la Culture et de la Communication*. We (the three team leaders) and Debard were joined by a team of specialist colleagues and a group of mainly student volunteers from several institutions: Alain Argant (Research Associate of UMR 7269 CNRS (LAMPEA), Université Aix-Marseille, Aix en Provence, France; fossil carnivores); Jacqueline Argant (Research Associate of UMR 7269 CNRS (LAMPEA), Université Aix-Marseille, Aix en Provence, France; palynology); Fabio Parenti (Istituto italiano di Paleontologia Umana, Rome, Italy; topography, mapping, drafting of fossil placement); Jean-François Pastre (Laboratoire de Géographie Physique, CNRS Meudon, France; volcanology, tephrochronology). Sevket Sen (Laboratoire de Paléontologie, Muséum national d'Histoire naturelle, Paris; paleomagnetism); David Reddy (American Museum of Natural History; informatics); and John A. Van Couvering (Micropaleontology Press, American Museum of Natural History; geology and stratigraphy). Andrea Valli (UCB-Lyon 1) and Angélique Monguillon (PhD candidate, UCB-Lyon 1) were charged with technical supervision of the student excavators. Our team of volunteers included students from the PhD Program in Anthropology, City University of New York (CUNY) Graduate Center: Karen Baab, Terence Capellini, Steve Frost, Suzanne Hagell, Kieran McNulty and Tara Peburn (Fig. 1.6); and students and volunteers from Lyon universities (UCB-Lyon 1 and Lumière-Lyon 2 unless otherwise indicated): Amandine Alphonse, Célia Beaudoin, Loïc Costeur, Marie-Anne Héran, Hélène Jousse, Samuel Maillot, Bernard Ménouret and Laurent Servant. During the course of the season (July 2–21), the site was visited by M.-P. Aubry (Rutgers University, USA), W. A. Berggren (Rutgers and Woods Hole Oceanographic Institution, USA), M. Grandjean (Musée Crozatier au Puy-en-Velay, France), C. Lécuyer (UCB-Lyon 1) and P. Noyaret (Association Saint-Vallier, Histoire et Archéologie, France).

Fig. 1.6 American team in 2001; left to right: J. van Couvering, K. Baab, S. Frost, S. Hagell, E. Delson, K. McNulty, T. Peburn, T. Capellini

We concentrated on work in parcels 233 and 234, near the hamlet of Senèze (see Fig. 2.3). The landowner for parcel 233 (termed the "champ Thomas" by Depéret and Mayet 1912) was Ms. Marguerite Limagne; and for parcel

234 M. Jean-Jacques Chabrier. They graciously allowed the team to survey and excavate on their land, and this permission was renewed in following years (as was true for landowners mentioned in later seasons). The team did not seek permission to work on land owned by the Philis family for two reasons: On the one hand, the terrain had been excavated in the first half of the twentieth century by P. Philis, and we wished to avoid problems with his backfill; moreover, the current owner, his grandson M. Omer Philis, was not ready to grant us authorization to excavate on his land (see below).

Two rented trailers (in French, "bungalows") were placed along the road between Senèze and La Chomette to serve as an office and a storage area each season (Fig. 1.7), next to a small rock face termed Section A, which turned out to include the youngest deposits in the area (see Debard 2024, for details about this and other trenches and sections studied). Three trenches were excavated by a backhoe (Fig. 1.8) at the start of the season: T1, in parcel 234, was 3 m deep, 2.5 m wide and 40 m long; T2, in parcel 233, was 3 m deep, 3 m wide and 15 m long; T3, also in parcel 233, lying perpendicular to T1 and T2, was 3 m wide and 20 m long. T3 was essentially sterile, while a cervid mandible and teeth were found near the base of T1; T2, on the other hand, proved fossiliferous. The backhoe revealed part of the skeleton of a rhinoceros lacking the cranium in T2 (*Dicerorhinus etruscus etruscus*, see Guérin 2024), which was excavated throughout the season (Figs. 1.9 and 1.10). Debard trained the students to draw the stratigraphy of these trenches to scale by using a grid placed against the exposed trench surface and drawing the visible contents of each grid square (Figs. 1.11 and 1.12). Samples were taken for sedimentological and tephric analysis. Any fossils recovered were photographed in place, located in three dimensions with a plane table and alidade (Fig. 1.13) or total station (see Fig. 2.4) and drawn onto a base map under the supervision of Parenti (see Figs. 2.5, 2.6 and 2.7). Details were entered into an Excel spreadsheet and a GIS program and assigned a sequential field number of the form SEN 01-#. This methodology, developed by prehistoric archaeologists, is commonly used for Plio-Pleistocene deposits.

Blackwell supervised the collection of samples to estimate the radiation dose rate for analysis of ESR age, and four dosimeters were emplaced in auger holes in the wall of T2 to be retrieved in 2002. Sen took paleomagnetic samples in T1 and T2 and in underlying basalts (Fig. 1.14; see Delson et al. 2024b), and J. and A. Argant sampled for pollen in T1 and T2 (Fig. 1.15; see J. Argant 2024). At the end of each season, a geotextile was laid over excavated areas to mark the level for opening the following year (Fig. 1.16), and the backhoe refilled the excavations to prevent farm animals from harming themselves.

Fig. 1.7 View of Trench 1 and Trench 2 (with sunshade), in center of image; to left team cars and office bungalow, to right hamlet of Senèze, background rising to rim of crater

Fig. 1.8 Backhoe excavating Trench 1

Fig. 1.9 Excavation and cleaning of rhino skeletal elements, 2001

Fig. 1.10 Partial postcranial skeleton of *Dicerorhinus etruscus etruscus* found in connection in Trench 2, 2001. **A** Part of right forelimb and ribs; **B** Part of right hind foot; **C** left forefoot; **D** part of left hind foot

Fig. 1.11 Three teams of two students each making scaled drawings of Trench 2 stratigraphy

Fig. 1.12 Closeup of H. Jousse and L. Servant making a scaled drawing in Trench 2

Fig. 1.13 F. Parenti mapping fossil finds with plane table and alidade, K. McNulty taking notes

Fig. 1.14 S. Sen sampling for paleomagnetism in Trench 2

Fig. 1.15 Sampling for pollen in Trench 2. Left to right: A. Argant, J. Argant, C. Beaudoin

Fig. 1.16 Placement of geotextile to mark the excavation level for next year before the trench is refilled by the backhoe, 2001

2002. As in all later years, Faure and the team leadership submitted a report of the previous season's work to the DRAC early in the year, along with a request for continued permission and funding. The 2002 field season was short (June 29–July 9), given limited funding. We were joined by Debard, Pastre, Monguillon, Valli and Héran (Fig. 1.17). The dosimeters were retrieved from the former site of T2, and some localized coring was undertaken by Pastre (Fig. 1.18). Several new areas were prospected for potential detailed study in following years.

Fig. 1.17 French team in 2002. Left to right: E. Debard, M.-A. Héran, M. Faure, J.-F. Pastre, C. Guérin, A. Valli, A. Monguillon

Fig. 1.18 J.F. Pastre preparing to drill a core in parcel 233, 2000, observed by A. Valli, A. Monguillon and E. Debard

2003. The third field season again lasted four weeks, from June 30 to July 26. Faure was granted a permit for planned excavation (fouille programmée), which was renewed annually through 2006. We were joined by Debard, Pastre and Reddy, along with Luca Aprile (Associazione Aditus in Rupe, Floridia, Italy; topography and mapping); Elvira Martín Suárez (Universidad de Granada, Spain; micromammal paleontology); and Abel Prieur (UCB-Lyon 1; fossil collection and preparation). Monguillon and Valli continued technical supervision of the student excavators. Students and volunteers (from UCB-Lyon 1 and Lumière-Lyon 2 unless otherwise indicated) included: Catherine Albouy, Olivier Ambrosini, Anthony Bailly, Adama Cisse, Guillaume Colombeau, Camille Daujeard, Mikaël Dumas, Clément Fay, Marie-Anne Héran, Russell Hogg (CUNY), Pierre Joris, Bénédicte Kay, Bernard Ménouret, Fabien Méras, Emilie Pijolat, Caroline Ramirez, Caitlin Schrein (Arizona State University), Michelle Singleton (Midwestern University, Illinois) and Isabelle Sobis. Visiting colleagues included: Pierre Élouard, Pierre Hantzpergue and Pierre Mein (UCB-Lyon 1), Véra Eisenmann (CNRS and MNHN Paléontologie), Evelyne Crégut-Bonnoure (Musée Requien d'Histoire naturelle, Avignon), George Lyras (University of Athens) and Sandra van der Geer (University of Leiden).

A surface for excavation was exposed in parcel 233 near the place where T2 had been dug two years previously; this was termed zone H8-N9-L14-G11. Additional fragments of the 2001 rhino were recovered, along with teeth of a cheetah (*Acinonyx pardinensis*) and teeth and foot bones of bovids and cervids (especially *Metacervoceros rhenanus philisi*). A partial tusk of a mammoth (*Mammuthus meridionalis*) was found nearby and excavated, then covered in a plaster jacket for transport (Fig. 1.19). Trench T4 was dug in parcel 174 (landowner Ms. Marie Lonjon) but proved sterile of fossils. J. Argant sampled for additional pollen in the area of the rhino skeleton of T2 and also located a number of coprolites (presumably of a hyaenid) nearby. Martín Suárez supervised sampling for micromammals by passing several tons of sun-dried sediment through a specially-designed screen-washing system (Fig. 1.20), but no identifiable specimens were recovered. In light of this effort (also in 2004), we must note that Eugen Huber, who undertook screen-washing for Stehlin and Schaub from 1916–1940, had immense good luck to find even a few rodent teeth as discussed above.

Fig. 1.19 Partial tusk of *Mammuthus meridionalis*. **A** After cleaning in place; **B** Jacketing in plaster, in order to protect it for transport (see Ménouret & Guérin 2024)

Sucheras, Jean-Alix Suy, Bérangère Tarka and Thi My Linh Vo. William Harcourt-Smith (AMNH postdoc) supervised training of three Lehman College (CUNY) undergraduate students (Randy Rampersaud, Roxanne Rivera and Jennifer Ross; see Fig. 1.21). Visiting colleagues included: Katherine St. John (Lehman College, CUNY), Kieran McNulty (Baylor University) and Tamara Munzner (University of British Columbia).

Fig. 1.20 E. Martín Suárez, assisted by student volunteers, washing dried sediment through screens in order to search for microfaunal remains

2004. The field season ran from July 1–31. Debard, Martín Suárez (and Matthijs Freudenthal, also from Granada and Naturalis/Leiden), Parenti (assisted by Federica Candelato, Vittorio Rioda and Maria Primicerio) and Pastre continued in their specialties. Students and other volunteers (from UCB-Lyon 1 and Lumière-Lyon 2) included: Audrey Crousilles, Julien Droz-Vincent, Véronique Fiastre, Stéphanie Guillerme, Marie-Pierre Guirado, Marie-Anne Héran, Mathieu Mazières, Bernard Ménouret, Guillaume Michel, Adrien Pozzi, Violette Ravel, Isabelle Sobis, Baptiste

Excavation surface H8-N8-L14-G11 was reopened in parcel 233 and yielded most of the postcranial skeleton of a deer, *Eucladoceros ctenoides senezensis* (Fig. 1.22, also Fig. 2.6; see Valli 2024). The screen-washing operation yielded a porcupine incisor, representing a new family for the site (Hystricidae, see Mörs and Hugueney 2017) and also one molar of a small rodent (*Mimomys pitymyoides*), as well as some artiodactyl teeth. A major excavation was undertaken in parcel 172, where trench T5 was dug perpendicular to the slope toward the center of the maar. It was some 30 m

long and 3 m wide, about 3 m deep at any one point but over 11 m in exposed elevation (Fig. 1.23). T5 yielded a partial skeleton and another partial cranium of *Eucladoceros*; articulated foot bones of horse (*Allohippus senezensis*, Fig. 1.24), rhino and artiodactyl; and teeth of bovids and cervids. Sevket Sen took samples for paleomagnetic analysis in T5, in zone H8-N8-L14-G11 and in a small pit about 1 m^2 in area and 2.5 m deep which had been dug along the northern edge of the same parcel (233) for that purpose. J. Argant sampled for pollen in T5.

Fig. 1.21 Lehman College undergraduates supported by NSF UBM award in 2004. Left, A. Valli helping R. Rivera (left) and J. Ross wash fossils; right, E. Delson showing R. Rampersaud how to clean fossils

Fig. 1.22 Left, excavation surface H8-N8-L14-G11 in parcel 233, 2004; right, closeup of students excavating postcranial skeleton of *Eucladoceros ctenoides senezensis*

Fig. 1.23 Trench 5, 2004; lower (inf) segment, with E. Debard and J.-F. Pastre, "step" and excavation surface and upper (sup) segment in shadow; total drop from land surface at back of upper segment to lowest point about 11 m, length ca. 30 m

Fig. 1.24 Partial foot of *Allohippus senezensis* from T5 "step", 2004

2005. The field season ran from July 4–30, with the team leaders accompanied by Debard, Pastre, Valli and Monguillon (who also took responsibility for topography and mapping-in of fossils). Students and other volunteers (from UCB-Lyon 1 and Lumière-Lyon 2 unless otherwise indicated) included: Vivien Aubry, Siobhán Cooke (CUNY), Céline Domergue, Sarah Freidline (CUNY), Pauline Girard, Stéphanie Guillerme, Alexandra Houssaye, Bernard Ménouret, Isabelle Sobis and Michael Steiper (CUNY).

Excavation surface H8-N8-L14-G11 was reopened in parcel 233 in an unsuccessful search for the skull of the *Eucladoceros* skeleton recovered in 2004. Work concentrated in parcel 172 where a smaller trench (T6) was opened near where T5 had been excavated (Figs. 1.25 and 1.26). In addition to smaller finds, a nearly complete skeleton of *Allohippus senezensis* was recovered near the base of the section (Fig. 1.27; see Eisenmann & Delson 2024, Fig. 11.24; also Fig. 2.7). In parcel 228, the naturally

Fig. 1.25 Trench 6, 2005 (left, during excavation; right, at the end of the season)

Fig. 1.26 Excavating equid skeleton near T6, 2005

Fig. 1.27 Skull of *Allohippus senezensis* partial skeleton from area alongside T6

exposed "Philis ravine", where P. Philis had recovered many fossils in the first half of the twentieth century, was cleaned and studied stratigraphically thanks to the permission of landowner M. Omer Philis, but no additional fossils were found.

2006. The field season ran from July 3–28, under the direction of Guérin and Delson (Faure was only available for part of the season), assisted by Valli and Monguillon (who also took responsibility for topography and mapping-in of fossils). Debard and Pastre supervised geological excavation and tephra sampling; J. Argant sampled for pollen. Yolanda Fernández-Jalvo (Museo Nacional de Ciencias Naturales, Madrid) studied the taphonomy, assisted by Valli. Students and other volunteers (from UCB-Lyon 1 and Lumière-Lyon 2 unless otherwise indicated) included: Florent Bartolucci, Hélène Bourget, Virginie Caup, Camille Clément, Audrey Crousilles, Erwan Ermel, Eva Garrett (CUNY), Christine Guingenaud, Hélène Lecas, Bernard Ménouret, Florence Olive, France Rousselières and Ilya Shmulenson (CUNY). In addition, James Delson (Eric's brother), his wife Jennifer and children Caroline and Robert spent several days volunteering on the site.

Another trench, T7, was emplaced in parcel 172 near where T5 and T6 had been (Figs. 1.28 and 1.29). A partial skeleton of *Allohippus senezensis* was found in the middle levels, where it had been held in place by large blocks; it was much less well preserved than the 2005 skeleton (see Eisenmann & Delson 2024, Fig. 11.25). To obtain additional stratigraphic data, trenches T8 and T9 were excavated nearby, but no fossils were recovered.

Fig. 1.28 Trench 7, 2006

Fig. 1.29 Team members cleaning and excavating in T7, 2006; **A** student volunteers; **B** E. Delson (photo by I. Shmulenson)

Other Senèze Research After 2000

A small number of publications focused on Senèze and its fossils have appeared since 2000, some of which have been mentioned above. Roger et al. (2000) sampled the 1989 cores for paleomagnetism and also discerned a thin (5 cm) volcanic tephra within the normal interval. This was dated by $^{40}Ar/^{39}Ar$ at 2.1 ± 0.1 Ma, which was suggested as the end of the Réunion subchron. The Senèze fauna was thought to lie above this level, following the work of Bout (1970a, 1970b) .

At the 2004 Weimar conference on Late Neogene and Quaternary faunas, Delson et al. (2004) reported the ongoing fieldwork at Senèze and Maul (2004) discussed Schaub's Senèze rodents (see above). Also in 2004, the site was

visited by members of the Association Française pour l'Etude du Quaternaire during a field excursion on Quaternary and vulcanism of Auvergne and Velay (Argant 2004; Debard & Pastre 2004; Faure et al. 2004). Delson et al. (2006) published a long summary of the Franco-American work at Senèze (in the proceedings of the 2004 conference). Nishimura et al. (2009) analyzed a CT scan of the unique holotype cranium of Senèze *Paradolichopithecus arvernensis*, reporting the lack of a maxillary sinus as found otherwise only in *Macaca* among extant Cercopithecinae (see Delson 2024).

Nomade et al. (2014) reported the results of a major campaign of argon dating French Villafranchian faunal horizons. Five dates were obtained from tephras collected by our team, resulting in an age range between 2.21–2.09 Ma. These ages were recalculated to current standards and compared to paleomagnetic sequences in Delson et al. (2024b). Pastre et al. (2015) presented a range of geological data from the Franco-American fieldwork, including material developed at greater length in Parenti et al. (2024), Debard (2024), Pastre (2024) and several of the mammalian systematic chapters, as well as a brief discussion of Villafranchian biochronology. A partial upper incisor recovered during the 2004 field season was identified as *Hystrix refossa* by Mörs and Hugueney (2017). Paquette et al. (2021) reported several U–Pb dates on zircon from a number of French Villafranchian sites (see Delson et al. 2024b), including one of 2.100 ± 0.029 Ma from Senèze.

Plan of This Volume

The focus of this book is the work undertaken from 2001–2006 by the Franco-American field project. The first four chapters after this introduction cover aspects of the techniques employed and the geological background to the paleontological results. In Chap. 2, Parenti et al. (2024) discuss their surveying of the site and the basic excavation techniques employed; they also present several maps and measured drawings of partial skeletons recovered during the fieldwork. In Chap. 3, Debard (2024) presents the stratigraphical framework of the site and discusses aspects of correlation among the numerous trenches and other sampled sections. Pastre (2024, Chap. 4) describes the volcanic context of Senèze and details of the tephras identified. In Chap. 5, Delson et al. (2024b) discuss the age of the site, based on a series of argon-argon dates (originally reported by Nomade et al. 2014, but recalculated here) and paleomagnetic "columns", suggesting that the Senèze fauna was deposited between 2.20 and 2.08 Ma, with the fossils from our fieldwork coming from two intervals ca. 2.20–2.18 and 2.10–2.08 Ma.

Three chapters then present non-mammalian paleontology. In Chap. 6, J. Argant (2024) discusses palynological finds and their implications for paleoenvironment. Gaudant (2024) describes some fossil fishes recovered from our excavations in Chap. 7. In Chap. 8, Mourer-Chauviré (2024) describes the birds from Senèze and considers their importance for reconstructing the paleoenvironment; seventeen species are recognized, including four extinct ones: *Pavo bravardi*, *Tetrao* cf. *partium*, *Surnia robusta*, and *Corvus corax antecorax*.

The fossil mammals from Senèze are discussed in detail in the following eight chapters. A. Argant (2024, Chap. 9) revises the carnivores in detail. Twelve species are recognized: four canids (*Nyctereutes megamastoides*, *Vulpes alopecoides*, *Canis arnensis* and *Canis* sp.), one ursid (*Ursus etruscus*), three hyaenids (*Pachycrocuta perrieri*, *Chasmaporthetes lunensis,* and an indeterminate hyaenid), and four felids (*Acinonyx pardinensis*, *Megantereon cultridens*, *Homotherium crenatidens* and a new record for Senèze, *Dinofelis* sp.). Guérin (2024) reviews the rhino, *Dicerorhinus etruscus etruscus*, in Chap. 10. He describes the large sample of this form from Senèze, including a newly recovered partial skeleton, 17 crania and numerous other elements. Eisenmann and Delson (2024) distinguish three genera of monodactyl equids (*Equus*, *Plesippus* and *Allohippus*) and review all equid specimens known from Senèze in Chap. 11. The great majority of fossils belong to *Allohippus senezensis senezensis*, with less than 20 identified as *Allohippus major*. There are also a few specimens either larger or smaller than the former. Faure and Guérin (2024, Chap. 12) discuss the suid *Sus strozzii*. No new specimens were recovered, but the previously known sample includes a nearly complete skeleton; the species is a good indicator of a forested environment with a wet and probably warm climate. In Chap. 13, Valli (2024) discusses the newly recovered cervid material of *Eucladoceros ctenoides senezensis* and *Metacervoceros rhenanus philisi*; *Croizetoceros ramosus minor* and *Cervalces gallicus* are also known from Senèze, but no specimens of these taxa were recovered during our fieldwork. Chapter 14 is a detailed review by Crégut-Bonnoure (2024) of the bovid taxa known from Senèze. She recognizes *Gazellospira torticornis*, *Procamptoceras brivatense*, *Gallogoral meneghinii*, *Pliotragus ardeus*, *Megalovis latifrons*, cf. *Hemitragus* sp., *Ovis claudiusguerini* nov. sp., *Leptobos etruscus*, *Leptobos furtivus* and Bovidae indet. *Bison* (*Eobison*) sp. is known from a donated specimen which appears to derive from a significantly younger horizon; one specimen of *Megalovis* was also donated from a different unknown horizon. In Chap. 15, Ménouret and Guérin (2024) review the remains of *Mammuthus meridionalis meridionalis* from the site, including the one partial tusk found in 2004. Delson (2024, Chap. 16) discusses the two primate specimens recovered by Philis from Senèze: a partial ulna assigned to *Macaca* cf.

sylvanus and the holotype skull of *Paradolichopithecus arvernensis*. The latter species is differentially diagnosed, and the Senèze specimen (one of the youngest known for this taxon) is described and compared to those of other *Paradolichopithecus* samples.

The last three chapters are analytical summaries. Crégut-Bonnoure et al. (2024) review the biochronological position of Senèze within the Villafranchian in Chap. 17, comparing the mammalian assemblage to those of the Massif Central (and Saint-Vallier) in France as well as to selected localities in Spain, Italy, the Netherlands and Germany. Senèze is distinguished from older sites (in MNQ 17) and clarified as the earliest in MNQ 18, which is estimated to begin about 2.2 Ma. The end date of this unit is discussed, whether close to 2.0 or 1.7 Ma, depending on which other localities are included in it. In Chap. 18, Fernández-Jalvo et al. (2024) discuss the taphonomy of large mammals from Senèze. They conclude that most animals found as fossils died after drinking at the lake shore and falling into the water, from which they were unable to escape and drowned. In Chap. 19, Delson et al. (2024a) provide longer summaries of each chapter's results and broader conclusions about paleoenvironment, faunal composition and site formation.

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