高温高压条件下电导率测量实验技术发展及在地学和材料科学中的应用

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物质的电导率是物质的组成、结构、构造以及所处热力学条件的综合反映，高温高压条件下电导率原位测量无论在地球科学、凝聚态物理学还是材料科学中都具有极为重要的意义。近几十年中，为解译野外地球物理数据存在于地球内部的电导率高导异常，国内外学者开展了高温高压条件下矿物岩石电导率实验研究，取得了重要进展。具体表现在：研究方法从最初的直流法发展为单频交流法和更先进的电化学阻抗谱法；对应于处于地球内部不同深度范围的中下地壳–上地幔–地幔转换带–下地幔–核幔边界–地核等地质体，开发出了适用于不同高温高压实验室设备（包括活塞圆筒、多面顶压机、金刚石压砧等）的电导率测量方法；针对电学性质的可能影响因素，国内外学者主要从温度、压力、氧逸度、成分、水含量、铁含量、碱金属离子含量、碳含量、脱水作用、脱氢作用、部分熔融、颗粒粒度、颗粒边界厚度等方面做了系统而深入的研究。

尽管与国外学者相比，国内高温高压岩石电导率起步较晚，但发展迅猛，在活塞圆筒、多面顶压机、金刚石压砧等高压设备上的电学性质研究均取得重要进展。早在 1985 年，中国科学院地球化学研究所地球内部物质高温高压重点实验室的谢鸿森研究员等，在 YJ–3000t 多面顶压机上采用直流法测量了铁橄榄石电导率[1]。1995 年，李和平研究员将电化学中的阻抗谱技术引入到中科院地球化学研究所地球内部物质高温高压重点实验室的高温高压下地球物质电学性质的原位测量中，自此我国高温高压下地球物质电学性质的原位测量研究步入了崭新的发展阶段[2]。利用交流阻抗谱技术，中科院地球化学研究所地球内部物质高温高压重点实验室的李和平、朱茂旭、王多君、代立东、胡海英、蒋建军、惠科石、李佳、孙文清、龚超颖、李鹏、周文戈、郭新转等在多面顶压机上对等壳幔矿物岩石的电导率进行原位测量，并把实验结果应用于全球稳定大陆地壳、壳幔边界、

青藏高原、秦岭大别山、俯冲带等全球或者某一区域典型的构造单元中普遍存在的低速高导异常的成因解释[3–18]。中国科学院地质与地球物理研究所的白武明、黄晓葛、柳江琳、黄小刚、王欣欣等，采用电化学交流阻抗谱法，在中国科学院地球化学研究所地球内部物质高温高压重点实验室的 YJ–3000t 多面顶压机上，对辉橄岩、黑云斜长片麻饭、碳酸盐化橄榄岩、苦橄质榴辉岩等岩石的电导率亦进行了系统的研究[19]。中国地震局地质所杜建国、白利平等在中国科学院地球化学研究所地球内部物质高温高压重点实验室的 YJ–3000t 多面顶压机上，对辉长岩和斜长岩电导率和弹性波速进行了系统研究[20]。此外，中国科学技术大学地球与空间科学学院倪怀伟教授研究团队、南京大学地球科学学院杨晓志教授研究团队等，在活塞圆筒上也做了大量的电导率研究工作[21-22]。近年来，中国科学院地球化学研究所地球内部物质高温高压重点实验室代立东研究员研究团队的庄毓凯、柳凯祥、杨林飞、蒲畅、洪梅玲等，将电化学交流阻抗谱法应用到金刚石压砧高压设备上，对金属硫化物矿物、石膏、高岭石、部分功能材料等的电学性质进行原位测量，并广泛应用于改善矿物和材料的物理学性能的研究中[23-28]。

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